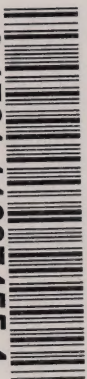


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# WATER MANAGEMENT RESEARCH: SOCIAL SCIENCE PRIORITIES

Sewell, Judy and Ouellet



Policy and Planning Branch  
Department of Energy,  
Mines and Resources  
Ottawa, Canada.

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# **WATER MANAGEMENT RESEARCH: SOCIAL SCIENCE PRIORITIES**

W. R. Derrick Sewell,  
Richard W. Judy and  
Lionel Ouellet

**Policy and Planning Branch  
Department of Energy,  
Mines and Resources  
Ottawa, Canada.  
1969**

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## PREFACE

Increasing demands on Canada's water resources caused by an expanding industry and a growing population have generated significant interest in problems and research related to the management of resources. The rising intensity of use of water results not only from a growing urban and industrial economy but also from the increased leisure time enjoyed by Canadians, permitting a greater amount of water-based recreation. The need therefore has developed to examine the varied array of social and economic implications associated with water management.

The papers contained in this publication present a broad view of the complex problems in managing a resource which concerns every sector of the economy. In addition to economic considerations, the authors discuss geographic, legal and administrative aspects. Written by authorities in their respective fields, the papers were edited by W.R. Derrick Sewell of the University of Victoria.

Because of the importance of water resources management to the welfare and economy of Canada, the Policy and Planning Branch of the Department of Energy, Mines and Resources is pleased to be associated with the authors in the publication of their papers.

J.W. MacNeill  
Director  
Policy and Planning Branch

## PRÉFACE

La demande croissante imposée sur les ressources hydrauliques du Canada, par suite de l'expansion industrielle et démographique, a suscité un vif intérêt pour les problèmes et la recherche en matière de gestion des ressources. L'intensité accrue de l'utilisation des eaux reflète non seulement une économie urbaine et industrielle en expansion mais également une augmentation des moments de loisirs des Canadiens qui leur permet de s'adonner de plus en plus à la récréation aquatique. Le besoin d'étudier l'éventail des implications sociales et économiques de la gestion des eaux s'est donc fait sentir.

Les documents contenus dans la présente étude offrent une vue d'ensemble des problèmes complexes qui se présentent lorsqu'il s'agit de gérer une ressource qui touche tous les secteurs de l'économie. Outre les considérations économiques, les auteurs exposent également les aspects géographiques, juridiques et administratifs. Rédigées par des experts dans leurs domaines respectifs, ces études ont été éditées par W.R. Derrick Sewell, University of Victoria.

En raison de l'importance que présente la gestion des ressources hydrauliques pour le bien-être des Canadiens et l'économie du pays, la Direction des politiques et de la planification du ministère de l'Énergie, des Mines et des Ressources est heureuse de collaborer avec les auteurs à la publication de ces études.

J.W. MacNeill

Directeur

Direction des politiques et  
de la planification



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The authors also wish to acknowledge the assistance of several people in the preparation of the volume. In particular they wish to thank Miss J. Elizabeth McMeiken for her untiring efforts in library research and in proof-reading the manuscript. They also wish to thank Mrs. L. Lewis who typed the final draft for publication, and Mrs. J. Mace who assisted in proof-reading.

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## CHAPTER 1

### THE NEED FOR SOCIAL SCIENCE RESEARCH IN WATER MANAGEMENT

W.R. Derrick Sewell

University of Victoria

One of the most significant features of the past decade has been the increasing public debate about the management and use of Canada's water resources. Water resource development has often aroused public discussion in Canada, particularly because such development has had important economic, social, and political consequences. What is new is the intensity and continuousness of the debate. Water problems have now become major issues in political campaigns. They have been the basis of bitter disputes between the provinces and the federal government, and between Canada and the United States. In recent years they have claimed an increasing proportion of the time of the House of Commons<sup>1</sup> and the various provincial legislatures as well as a growing amount of attention in the various media of mass communication.

#### The Recent Awakening of Interest in Water Problems

There are several reasons for the recent awakening of public concern about water problems in Canada. One of them is the increasing competition for the use of particular rivers or lakes resulting from population growth, urbanization, and industrialization. In

some cases this competition has led to major conflicts of interest.<sup>2</sup> The use of water bodies for waste disposal, for example, has come into conflict with the use of such bodies for other purposes, such as domestic and industrial water supply, and recreation. There are examples of this all over the country.<sup>3</sup> In some regions, such as Quebec and the Maritimes, log driving has come into conflict with the development of hydro-electric power. In British Columbia bitter disputes have arisen between fishery interests and log driving interests<sup>4</sup> and between fishery interests and hydro-electric power interests.<sup>5</sup> Such conflicts are certain to increase both in number and in complexity in the years ahead.

Another reason for the growing public concern about water problems stems from the increasing demand for a higher quality environment. Canadians are no longer satisfied with merely increasing their income. They also wish to improve the environment in which they live, work and recreate. Suddenly an awareness of the effects of urbanization and industrialization has developed. Problems of water and air pollution are now among the most popular topics of public discussion. At the same time, increasing affluence has led to an increase in leisure time. This in turn has given rise to growing demands for outdoor recreation, and particularly water-based recreation.<sup>6</sup> More and more pressure is being placed on governments to deal with pollution problems and to expand opportunities for outdoor recreation.

A third source of public debate relates to the roles that the various levels of government can most appropriately play in developing the nation's water resources. The British North America Act, 1867, specifies under Section 92 that the provinces own the resources within



their territory (with certain important exceptions, such as resources in National Parks or in the Territories) and that apart from the jurisdiction allocated to the federal authority for navigation, fisheries management, and the solving of interprovincial disputes and international problems, and apart from the federal authority's co-jurisdiction in matters relating to agriculture, the provinces are free to develop and manage these resources in whatsoever way they wish.<sup>7</sup> Except for those water uses for which it has direct responsibility, and apart from matters concerned with international rivers, the federal government has played a largely passive role in water development in Canada.<sup>8</sup> It has become increasingly apparent in recent years, however, that many water problems by their nature and magnitude are of greater than provincial concern, particularly in cases where water resources are shared by more than one province, or where provincial financial resources are not adequate to ensure efficient development. Discussion is now focussed upon the problem of finding ways in which provincial governments can retain autonomy in resources management but at the same time enable the federal government to play a more active role than it has in the past.

Proposals relating to the diversion of water from Canada to the United States have also been the subject of widespread public discussion. Among the various proposals, the NAWAPA scheme<sup>9</sup> and the Grand Canal scheme<sup>10</sup> have received particular attention. Although it is widely claimed that Canada possesses vast water resources, opinion is divided as to whether, and under what circumstances the export of water to the United States should be sanctioned.<sup>11</sup> The arguments against export rest mainly on claims that "Canada may need the water in the future" or that "export today may mean higher cost

water for Canadians tomorrow". Unfortunately it is not possible to appraise the validity of these claims as data relating to water use in Canada and as to probable costs of developing new sources of supply are presently lacking.

A fifth source of debate about water management in Canada stems from the increasing volume of public funds devoted to the development of water resources. While no precise figures are available relating to total investment in this connection, data relating to a few of the major projects emphasise that the volume is large.<sup>12</sup> It also appears that as the magnitude of projects goes on increasing and as the demand for such collective goods as recreation and de-pollution continues to expand, this volume and the relative share of investment contributed by the public sector will continue to grow.

Discussion stemming from the various problems noted above has brought into question the adequacy of present policies, laws and administrative arrangements in the field of water resources management in Canada. Although it has frequently been suggested that changes need to be made, there has not been any broad agreement as to what these changes should be. The improvement of policies, laws and administrative structures will hinge in part on a considerably expanded research effort to improve understanding of how much water there is, what it can be used for, in what ways it can be developed and managed, and what effects various policies are likely to have.



The Nature and Extent of Water Resources  
Research in Canada

Given the increasing number and complexity of water resources problems in Canada, what are the types of research that would be most useful in helping to find solutions to these problems? What is the nature and extent of the present research effort relating to water management in Canada and what priorities should be assigned to future research? These questions provided the principal focus for studies undertaken recently by the Science Secretariat of the Privy Council<sup>13</sup> and by the Science Council.<sup>14</sup> These studies revealed that the present research effort is extremely small and is fairly narrowly focussed. At present just over eight million dollars a year is spent on water resources research in Canada.<sup>15</sup> This represents about one per cent of the total annual investment in research and development in this country.<sup>16</sup> More significant perhaps is the fact that it is less than one per cent of the annual investment in the construction of water control works in Canada.<sup>17</sup>

Most of the water resources research undertaken in Canada to date has been focussed on the physical dimensions of the resource and its management, principally the study of (a) various components of the water cycle and (b) water quality management and control. At present, some 77 per cent of all the funds invested in water research in this country is spent on these two topics.<sup>18</sup> In contrast, only a tiny fraction of the total funds is spent on research relating to the dimensions of water management. At present only \$280,000 a year is spent on such research, that is, less than 3.3 per cent of the total investment in water research.<sup>19</sup>

The Science Secretariat and the Science Council both called for a massive increase in the present research effort. To stimulate this effort, they suggested that research funding should be expanded from its present level of \$8 million a year to reach a level of \$25 million a year by 1972-1973.<sup>20</sup> Particular attention, it was suggested, should be paid to accelerating the research effort in the social sciences. The Science Secretariat recommended a gradual increase in funding, to reach a level of \$1 million by 1972-1973.<sup>21</sup> An important step was made last year towards attaining this goal. The Department of Energy, Mines, and Resources established a National Advisory Committee on Water Resources Research, with an initial funding of \$250,000 for social science research and another \$250,000 for research on physical aspects.

#### Towards an Expansion of Social Science Research

The small magnitude of social science research relating to water management in Canada is in part a reflection of the lack of a perceived urgency for such research until very recently. Even though the problems are now more clearly seen, and there is an apparent willingness on the part of the federal government to lead the way in providing more funds, it would be naive to expect that all of the studies that are required will be undertaken immediately. Several problems will have to be overcome before the needed expansion of social science research takes place.<sup>22</sup>

Perhaps the greatest scarcity is that of personnel to undertake the studies. In Canada we are not training, and retaining, enough high calibre social scientists to work in the water resources field.



This is due in part to the slowness with which graduate studies have developed at the Universities, and in part to the lack of employment opportunities for social scientists in water resources agencies. Two consequences have been for those who are interested in this field to move to the United States to obtain their training, and for many of them to remain there afterwards, because job opportunities for those with such a specialization have been plentiful.

Another deficiency of the past approach has been the heavy reliance on a very few agencies to provide funds for water research. In the social sciences the Canada Council was about the only agency through which funds could be obtained for such research. Where federal government Departments provided funds for water studies, they were generally interested in physically-oriented topics. Few provincial government agencies have funded social science research in water management. Perhaps the greatest gap in the funding mechanism has been the absence of a Foundation interested in water resources research. An organization similar to Resources for the Future, Inc. in the United States would have been extremely valuable.<sup>23</sup>

There are signs that many of the above deficiencies are being remedied. Several Universities in Canada have established graduate programmes which provide for a specialisation in water resources studies.<sup>24</sup> In some cases the social sciences are included as an integral part of these programmes. In addition, the employment opportunities for economists, lawyers, geographers, political scientists, and sociologists specializing in water resources have expanded considerably in the past five years. The demand for some of these specialists is so great in fact that positions have remained unfilled in

certain cases for more than a year! There also seems to be a broadening of the base of research funding. Not only has the federal government increased its commitment, but several provincial water resources agencies have begun to fund projects in the social sciences.

Specific suggestions as to ways in which the research effort in the social sciences might be stimulated further are set out in the chapters which follow.

### Contents of this Volume

This volume contains detailed reviews of the types of research that are needed in four major fields of social science--economics, geography, law and political science. These are presented in the chapters which follow. The reviews are not intended as consensus reports of the disciplines that are covered. Rather they represent the views of the author responsible for the chapter. Generally, however, opinions about the state of the art and the directions that future research should take are based on views that are widely held by those active in water resources research in the particular discipline involved. Some disciplines in the social sciences are not included--notably sociology, and psychology. Work is urgently needed in these fields, as is pointed out in this volume. Hopefully, more detailed reviews of the research needs in these disciplines will be forthcoming in the near future.

Chapter two examines the research needs in the field of economics. Professor Judy notes that Canadian economists have shown very little interest in water resources research until relatively recently. He points out that while Canada can benefit a great deal from what has



been learned from research in the United States, important gaps remain. He details various types of studies that are needed in this connection. Professor Judy stresses that when there are so many problems still to be solved, and many of them very basic problems, it is difficult to assign priorities. He singles out three broad areas of research, however, for urgent attention, namely, (a) demographic and economic base studies; (b) industrial, residential, and agricultural water demand studies; and (c) digital simulation models for complex systems analysis.

Chapter three is concerned with potential contributions by Canadian geographers. Professor Sewell reviews the research effort to date in this connection, noting that while Canadian geographers have long been interested in water management problems, the focus of their studies has been confined mainly to three main lines of enquiry: factors affecting the distribution of water resources, the development of water resources in particular regions, and the influence of various factors in decision-making. Over the years, however, there has been a slight shift in emphasis from physical to human dimensions, and a general advance in the sophistication of geographical studies. He suggests four principal areas of research for future geographical enquiry: namely, the estimation of the magnitude and possible use of Canadian water resources; the analysis of spatial impacts of development; the influence of institutional constraints on the formulation and the implementation of resource development plans; and the role of attitudes and perceptions in decision-making.

Chapter four is focussed upon problems and research needs

relating to law and administration. Professor Ouellet emphasizes that many of the most urgent problems in water management in Canada concern the institutional framework within which such management takes place. A number of especially difficult problems have arisen in recent years which will require adjustments in the present legal and administrative frameworks. These relate principally to the increasing scale of development (bringing about growing demands for capital), the broadening impact of water use (as is illustrated by water pollution and the competition between different water uses), and changing views as to the appropriate roles of various levels of administration in the management of water resources. Questions have been posed as to what should be the role of the federal government, what is the most efficient allocation of responsibilities among agencies at a given level of administration, and what is the best areal unit for organizing water management.

Professor Ouellet suggests that attempts to answer these questions have been frustrated so far by the lack of an acceptable framework of analysis that is based on concepts of administrative theory. He contends that the development of such a framework should receive top priority in the fields of water resources research in law, political science, and public administration. His chapter presents an outline of a possible framework, and suggests how it might be applied to the examination of present problems of water law and water administration in Canada.



## FOOTNOTES

1. During the period 1955-1960, for example, problems relating to water resources came up for discussion in the House of Commons a total of 1,583 times. In the period 1960-1965 such problems arose a total of 3,650 times. The increase in the latter period is accounted for largely by problems relating to the development of the Columbia River, the fluctuating levels of the Great Lakes, and the growing concern about pollution.
2. For discussions of these problems, see Canadian Council of Resource Ministers, The Administration of Water Resources in Canada, Montreal, 1965, and K. Kristjanson and W.R.D. Sewell, "Water Management Problems and Issues in Canada," Resources for Tomorrow Conference Background Papers, Ottawa: Queen's Printer, 1961, Vol. 1, pp. 205-210.
3. See Canadian Council of Resource Ministers, National Conference on Pollution and Our Environment, Background Papers and Proceedings, Montreal, 1966.
4. A particularly complicated dispute has arisen between the B.C. government and the federal government over the use of the Stellako River for log driving purposes. The provincial government has ignored a federal government order forbidding log driving on the river. The federal authority claims that this activity will eliminate the salmon runs but the provincial government says there is no proof of this. Thus far the federal authority has taken no action to prevent the log drives.
5. For a discussion of the Fraser River fish versus power problem, see W.R. Derrick Sewell, Water Management and Floods in the Fraser River Basin, Chicago: University of Chicago, Department of Geography Research Paper No. 100, 1965.
6. For a discussion of increasing demands for recreation in Canada, see Lloyd Brooks, "Demand for Recreation Space in Canada," in Regional and Resource Planning in Canada, Ralph R. Krueger, F.O. Sargent, A. de Vos, and Norman Pearson (Eds.), Toronto: Holt, Rinehart and Winston, 1963, pp. 200-211. For a discussion of increasing demands in a region, see J. Howard Richards, "Gross Aspects of Planning and Outdoor Recreation with Particular Reference to Saskatchewan," Canadian Geographer, Vol. XI, No. 2, 1967, pp. 117-123.

7. See Bora Laskin, "Jurisdictional Framework for Water Management," Resources for Tomorrow Conference Background Papers, Ottawa: Queen's Printer, 1961, Vol. 1, pp. 211-226.
8. T.M. Patterson, "Administrative Framework for Water Management," Resources for Tomorrow Conference Background Papers, Ottawa: Queen's Printer, 1961, Vol. 1, p. 245.
9. The NAWAPA scheme is described in U.S. Senate, Committee on Public Works, Special Subcommittee on Western Water Development, Western Water Development, Washington, D.C.: U.S. Government Printing Office, 1966.
10. The Grand Canal scheme is described in Thomas W. Kierans, "The Grand Canal Concept and the Great Lakes," in Canada, House of Commons Standing Committee on Mines, Forests, and Waters, Minutes of Proceedings and Evidence, No. 9, Ottawa: Queen's Printer, March 11, 1965.
11. For a summary of the various viewpoints, see W.R. Derrick Sewell, "A Continental Water System: Pipe Dream or Practical Possibility?" Bulletin of the Atomic Scientists (September, 1967), pp. 8-13. See also Blair Fraser, "Water Crisis Coming," Macleans (March 5, 1966), pp. 7 and 30-33; and T. Lloyd, "A Water Resource Policy for Canada," Canadian Geographical Journal, Vol. 73, No. 1 (July, 1963), pp. 2-17.
12. Major publicly-financed water development projects constructed in Canada in recent years include the St. Lawrence Seaway and Power Project (over \$500 million); the Columbia River Treaty Scheme (to cost some \$450 million by completion in 1973); the Peace River project (to cost some \$700 million); the South Saskatchewan River project (to cost some \$138 million for reservoir construction and installation of power generating facilities).
13. J.P. Bruce and D. Maasland, Water Resources Research in Canada, Privy Council of Canada, Science Secretariat, Special Study No. 5, Ottawa: Queen's Printer, 1968.
14. Canada, Science Council, A Major Program of Water Resources Research in Canada, Report No. 3, Ottawa: Queen's Printer, 1968.



15. Bruce and Maasland, op. cit., p. 26.
16. Ibid., p. 57.
17. Ibid., p. 27.
18. Ibid.
19. Ibid., p. 82.
20. Ibid., p. 64.
21. Ibid.
22. For a discussion of problems of stimulating the needed research, see W.R. Derrick Sewell, The Contribution of Science Research to Water Resource Management in Canada, Special Report prepared for the Privy Council Science Secretariat, Ottawa: Queen's Printer, 1968.
23. Resources for the Future, Inc. is a Ford-Foundation-sponsored research organization, based in Washington, D.C. It employs a small staff of a high calibre researchers, some of whom are employed on a permanent basis, and others who are in residence for a period of several months or a year. It undertakes independent research and it provides advice to the government when called upon to do so. It also provides funds for research at universities, both that which is undertaken by professors and that which is undertaken by graduate students. It has funded some studies in Canada.
24. Canadian Council of Resource Ministers, Graduate Resource Management Programs in Canadian Universities, Montreal, P.Q., 1967.

## CHAPTER 2

### ECONOMIC PROBLEMS IN WATER RESOURCES MANAGEMENT IN CANADA

Richard W. Judy  
University of Toronto

#### The Growing Interest in Economic Aspects of Water Management

During the past decade there has been a growing interest among Canadian economists in problems of water management. Until about ten years ago such problems did not interest them very much. In the period 1938 to 1968, for example, only six articles relating to water problems appeared in the principal Canadian economics journal.<sup>1</sup> Very few books or monographs by Canadian economists were published that had to do with water management. It was mainly engineers, historians, and geographers that were discussing water problems. Things have changed however in the past few years. Many articles have appeared in professional and technical literature by Canadian economists.<sup>2</sup> Economists have been appointed to several important posts that are concerned with water resources decision-making.

The recent upsurge in interest in water problems by Canadian economists is understandable. In part it stems from the burgeoning investment in water resources development in Canada. Projects costing

several hundred million dollars are now underway in various parts of the country, and others are on the drawing boards. Annual investment in water resource development in Canada has now exceeded a billion dollars.<sup>3</sup> This represents about ten per cent of total annual investment in Canada. Economists have become concerned about such investment, partly because it is so large, partly because it is such a major proportion of total investment, and partly because so much of it is in the public sector. They have begun to ponder the implications of these trends, and to ask whether the objectives to be served might not be pursued more efficiently by other means.<sup>4</sup> More specifically, they have begun to enquire whether the most efficient way to deal with a water "shortage" is to build another reservoir or to raise the price of water. They have also begun to ask whether investment in water development does in fact lead to regional economic growth, and if it does, whether it produces better results than investment in some other form of activity. In addition, questions have been raised about the economic implications of present criteria for allocating water between competing users. Are law and historical precedent satisfactory guides in such allocations? What might be the contribution of principles of economics to the development of criteria for this purpose?

The search for such criteria is not new, nor is it peculiar to the Canadian scene. It has been going on for some time, and in other countries too, and especially in the United States. It has sparked a good deal of research in that country, and some important advances have been made in water management as a result. Major gaps in understanding, however, remain.<sup>5</sup> Much can be learned from the progress that has been made in the United States and elsewhere but it is clear that there is still an urgent need for both basic and applied research on the economic aspects of water management in Canada.



This chapter has four main purposes, namely: (a) to identify the economic research needs in the field of water management in Canada; (b) to establish what research has been undertaken in Canada, the United States, and elsewhere; (c) to identify the constraints that might inhibit an expansion of research efforts in this field in Canada; and (d) to recommend priorities for research on the economic aspects of water management in this country.

Many aspects of water management are but special cases of more general problems of resource allocation, particularly in the public sector. Greater understanding of the relationship of water management to economic development, and the tracing of impacts of particular projects, therefore, hinges in part on advances in general economic theory and on the development and refinement of various tools of economic analysis. The first section of this chapter examines the relevant aspects of economic theory that have a bearing on water management and notes weaknesses in such theory. It also discusses various tools of analysis that may be used in the examination of water development projects, such as benefit-cost analysis, mathematical models, operations research, and computer science.

Rational water resources management requires planning for the future. A key element in such planning is the projection of the future economic and social environment. How large is the future population likely to be and what will be its characteristics? What kinds of economic activities may be anticipated to evolve? How are social tastes likely to change? An attempt to answer these questions may be made through the undertaking of base studies relating to demographic trends, shifts in the distribution of income, composition of industry, and so forth.

The second section of this chapter focusses on the types of base studies that are required for water resources planning.

A critical element in water resources planning is estimating the volumes of water that will be demanded by various types of uses--domestic, industrial, agricultural, recreational, and so on. Development of forecasts of future water demands, however, is extremely complex. The third section describes factors that need to be taken into account in such forecasts and notes types of studies that are needed to improve present forecasting methods.

Another important element in rational water resources planning is the analysis of past experience. Studies are needed to determine whether specified goals were attained and whether unanticipated effects were realized. Such post-mortem examinations provide an invaluable feedback mechanism in the planning process. The fourth section of this chapter details types of case histories and post-mortem studies that would be especially useful.

Water resources planning has become increasingly sophisticated in recent years, particularly as a result of the melding of contributions of various disciplines, and through the adoption of systems analysis techniques. The fifth section describes this progress but notes some of the difficulties of applying the "ideal" frameworks that have been developed. It identifies some of the important research needs in this connection.

It is clear that there remain important gaps in our knowledge relating to the economic aspects of water management and that much further research is required. Not all the studies can be done at once and

so it is necessary to assign priorities. The final section identifies three major types of research as top priorities. It suggests policy changes that would be likely to lead to an expansion of research in the needed areas.

### Theoretical Research

The theoretical approach and analytical tools which contribute to efficient water resource management are closely akin to the approaches and tools which contribute to efficient management in the fields of transportation, national defence, public health, education, and other fields of public activity. The needs of water resource management and the operational problems of national defence have been among the most important instigators of improved tools of economic analysis during the past quarter century.<sup>6</sup> In turn, the progress of economic science has multiplied and strengthened the management tools available to decision-makers in these two fields. While they are of considerable power, the existing tools of economic analysis need to be further strengthened and augmented.

### Welfare Economics

Most people would probably agree that the objective of water management should be the maximization of social welfare. Welfare economics is that part of economics which is concerned with the evaluation of the social desirability of alternative economic states.<sup>7</sup> Welfare economics is not an easy field; many conceptual problems remain to be resolved before the admonition "maximize social welfare" can be translated into an adequate set of guides to aid decision-makers in realistic management problems.

To achieve a social welfare optimum, water management



should seek to maximize the present value of a stream of net social benefits, i.e., the difference between streams of discounted social benefits and discounted social costs. Unfortunately, the specification of the appropriate objective function presents difficult theoretical and empirical problems to decision-makers in water management. The conceptual specification and actual construction of social welfare functions need research.<sup>8</sup>

. Any attempt to measure the benefits of public investment in water resources development requires a social welfare function to be defined. This may surprise some analysts who have been performing "benefit-cost analysis" and who have never heard of a social welfare function. Nonetheless, a social welfare function is implicitly or explicitly defined whenever one attempts to compare alternative economic states. The desirability of working with explicit and consistent criteria for measuring social welfare seems too obvious to require elaboration.<sup>9</sup>

According to one frequently adopted social welfare function, the gross benefits of a water resource project can be measured by summing the amounts of water which the project's beneficiaries would be willing to pay for the services which they would receive should the project be completed. To measure the "willingness to pay", it is logically necessary to estimate the amount of what economists call "consumer's surplus". Economic research which results in strengthening the conceptual foundations and the practical tools of measuring consumer's surplus will contribute appreciably to the art of water resource management.<sup>10</sup>

It is logically impossible to compare the desirability of alternative economic states without making implicit or explicit assumptions

about the adequacy of income distribution under the various alternatives. Water resources development projects and measures typically cause shifts in the distribution of income among members of society. Such re-distributions may benefit one geographical area while it harms another; it may reward one class of citizens at the expense of another class. Because of this, it seems prudent to define the objective of water resources management in many specific instances as the maximization of social welfare (measured in some unambiguous way) subject to certain constraints on the direction and extent of income re-distribution. Research is needed into the theory and practice of specifying such income re-distribution constraints.<sup>11</sup>

Social welfare optimization in water resource management must, inevitably, be optimization under constraint. A second important set of constraints within which water resource decision-makers must work concern the institutional structure of public and private bodies. The B.N.A. Act divides the responsibility for water resources management, albeit none too clearly, between the federal and provincial governments. Practice and precedent have endowed various levels and agencies of governments with powers and responsibilities in this field. Research is needed to further develop the tools of optimization under such institutional constraints and of evaluating the "shadow prices" of continued observation of the constraints. When the public and its elected officials are provided with such "shadow prices", they should be better able to judge the desirability of retaining or changing the institutional structure.<sup>12</sup>

Two phenomena, both highly characteristic of water resources projects and management measures, which have long been recognized by welfare economists as being inimical to efficient resource allocation

within a market system are indivisibilities and externalities. One or both of these factors usually lies behind the decision to entrust water resources management to public bodies. But that is not the end of these two trouble makers; they undermine the measurement of costs and benefits, and they frustrate the search for efficiency even when decisions are made by public bodies. More research is needed to develop adequate means of handling indivisibilities and externalities in water resources management systems.<sup>13</sup>

The relevance of the notion of opportunity costs has long been perceived by sophisticated analysts of public project costs. Unfortunately, the proper measurement of opportunity costs has frequently failed to find its way into the actual evaluation of project costs. The recent literature describes some of these unfortunate failures and admonishes project planners to take full cognizance of the opportunity costs of the alternatives confronting them. For such admonitions to be fully implemented, more research is needed on the identification and measurement of opportunity costs which are relevant to projects in water resource management.<sup>14</sup>

A deficiency of many prescriptions of welfare economics is that they are based on an assumption of perfect certainty. Real decision-making in water resources management always takes place under conditions of imperfect certainty. Much progress has been made during the past two decades in the development of theory and tools of decision-making under uncertainty. Much remains to be done and further progress here will have important payoff via improved allocative decisions in the field of water resources management.<sup>15</sup>

Both the costs and the benefits of public investment in water



resources management are distributed over time. In order to render commensurate the net benefits of alternatives, some method is required to reduce costs and benefits at different points in time to a common denominator. This is done by discounting the streams of costs and benefits to a present value by means of discount rates. Because water resource projects are typically long lived, the relative desirability of projects is highly sensitive to the selection of the discount rate. Considerable controversy has surrounded the selection of a proper rate of social discount. Progress has been made in recent years to clarify the issue but considerable obscurity remains. Research investment in this area should return significant dividends in improved decision-making.<sup>16</sup>

### Econometrics

Econometrics has been defined as "the social science in which the tools of economic theory, mathematics, and statistical inference are applied to the analysis of economic phenomena".<sup>17</sup> Economic theory aims to describe the important relationships existing among entities of an economic system. Expressed by means of symbols, these relationships form a mathematical "model" of the economic system or sub-system which they purport to characterize. Statistical inference is used to estimate numerical values for the parameters of the model. The estimates are made on the basis of data collected or generated for the investigation at hand.

Water resources management systems are embedded in larger and more complex systems. Two of the most obvious and most important of such systems are geophysical and economic in nature. As a sub-system of a larger economic system, the water resources management system is linked to other parts of the economy by many complex inter-

relations. The water management system requires inputs of labour, capital, materials, and other factors from the rest of the economy. As outputs, the water management system provides water-based services which are demanded by consumers and producers in the economy. Econometric models have important roles to play in the design and operation of improved water management systems. For this reason, support of econometric research will have an important payoff.

One of the most important empirical tasks of water resources management in Canada is the estimation of demands for water-based services.<sup>18</sup> It is precisely the tools of econometrics which will prove most valuable in deriving these demand functions. Statistical demand analysis is an advanced field of econometrics but more work remains to be done in developing econometric tools for demand function estimation of non-priced outputs, e.g., water-based recreation. Another area of econometric research which should bear fruit in improved water management concerns the field of cost estimation models.<sup>19</sup>

One of the points to be stressed most strongly in this chapter is that intelligent water resources management cannot proceed in the absence of plans or projections of the future economic environment in which the water resources management system is to operate. For this reason, the interests of rational water resource management demand the existence of well formulated models of the economic regions in which water resources will play a role. Research is needed to improve the tools and techniques of regional econometric model building.<sup>20</sup> Support is needed for further work in input/output analysis and computerized simulation models of regional economic systems. Support is needed not only for the actual empirical development of such models, but for the further development of the methodology of constructing them.

### Economic Mechanisms and Organizations

One of the most significant new directions of recent years in the literature of water resources management has been the growing emphasis on the role of non-structural measures. The possibility of improving water resources management by better institutional design and rational pricing is not yet fully perceived. More research is needed into the theory and practice of designing optimal organizational structures, information systems, and pricing mechanisms.

Research should reveal the relevance of the theory of markets, organization theory, and the theory of teams for the design of water resource management institutions. A main objective of such research would be to perfect the technique of designing institutions in such a way as to internalize important externalities in the water management field. Studies are needed of the superiority of centralized versus de-centralized decision-making systems. The theory of planning needs to be further developed and applied specifically to water resource management problems.<sup>21</sup>

### Mathematics, Operations Research, Computer Science

Because water resource management systems and the economic and geophysical systems with which they are closely related are so complex, powerful tools are needed for their analysis. Both economics and geophysics must make heavy use of mathematics and computer science. Progress in the development of better mathematical and computer techniques should yield rich dividends in perfected management tools.

Research is needed to develop improved methods of mathematical



programming and other optimizing techniques. In order to achieve results from such mathematical programming models, advancement is needed in the art of deriving numerical solutions of such problems.

Representation of water resource management systems by traditional mathematical models is hampered by the great complexity of those systems. The advent of digital and analogue simulation techniques has greatly enhanced the analyst's ability to study the complex interactions of elements within these systems. Simulation holds great promise as a means of representing complex systems and evaluating the effectiveness of alternative projects and measures. More research is needed to further the development of simulation techniques as a means of complex systems analysis.<sup>22</sup>

#### Base Studies

Canadian water resource systems to be managed are sub-systems of larger geophysical, economic, and demographic systems. For rational water resource management to proceed, the future environments provided by these larger systems must be planned or projected. Economic and demographic base studies are essential for such planning or projections.

#### Regional Planning and Projection

Many water-based services are consumed directly by the population. Others are provided to consumers indirectly via the production of other goods and services. To rationally assess the future demand for such water-based services as municipal water supply, pollution abatement, and recreation, it is obviously necessary to have adequate demographic projections.<sup>23</sup> Regional demographic studies for all the populated

areas of Canada should be prepared. These should indicate anticipated urbanization, regional migration, and other aspects of population change for at least the next twenty years.

Industry and agriculture generate heavy demands for water and water-based services. Regional economic plans and/or projections should be prepared indicating anticipated industrial and agricultural growth.<sup>24</sup> Because the adequacy of water services may influence the extent of that growth, the regional growth studies should be based on alternative assumptions about water availability, quality, and cost. The influence of technological progress should be anticipated to the extent that it is feasible to do so. Technological change can be expected to directly affect the demand for water and water-based services to the extent that it affects the rates of technical substitution of those services for other factors of production. Less directly, technology will affect water demand via its impact on the growth and decline of various industries.<sup>25</sup>

Changing patterns of employment, income, and leisure time will alter the nature and extent of demands for water-based services. To illustrate, as the disposable incomes and leisure time of North Americans increase, it is obvious that the demand for recreational facilities will increase also. To estimate the impact of this increased demand for recreational facilities on Canadian water resources, it is necessary to have projections of population, disposable income, and leisure time.

Water resources development, transportation, and land use patterns are bound together in a web of interdependence. To be able to

assess the costs and benefits of water resource developments, forecasts of transportation facilities and land use patterns are necessary. Such projections should be based on alternative assumptions about the availability, quality, and cost of water.

#### Public Investment other than in Water Resources

It is a commonplace that the benefits and costs of water resource development often include economies and diseconomies external to the authority bearing proximate responsibility for water resources management. Furthermore, the magnitude of the benefits which may be realized from water resource development depends heavily upon the private and public economic activity in the area which can benefit from that development. Demographic and economic plans and projections can aid the estimation of benefits to be realized by the population and private industry. Because all levels of government undertake or sponsor substantial investments in areas other than water resources, information relating to plans for such public investments is valuable grist for the mill of benefit-cost analysis. Since public investment in fields other than water resources may be conditional upon the availability, quality, and cost of water-based services, an informational clearing house of public investment plans should provide an important co-ordinating function.

#### Federal, Provincial and Social Targets, Constraints and Policies

The purpose of base studies is to provide an informational background for water resources planning and management. It was argued above that base studies should illuminate regional demographic and economic plans and projections as well as public investment plans. In addition, information about other salient social policies should be provided to water resource decision-makers when those policies operate to constrain



the social welfare maximization problem of water resource management. Such policies may concern governmental plans to effect income re-distribution among regions or income classes. They may also concern national goals or international trade and foreign exchange.<sup>26</sup>

### Accomplishing Demographic and Economic Base Studies

Demographic and Economic studies of regional development are important in many fields other than water resources management. For this reason, such studies should be carried out with the participation and support of other public and private agencies. Scores of federal, provincial, and local planning groups are engaged in research efforts which amount to what we have here called "base studies".<sup>27</sup> For the purposes of decision-makers in water resource management, the important points are (1) that such studies be produced and periodically updated by competent economic researchers, and (2) that, wherever possible, they reflect considered governmental policy. At a minimum, they should be consistent with public objectives concerning employment, economic growth, income distribution, and balance of payments. From the point of view of water resources decision-making, it would be desirable to have more detailed information about economic targets similar to those produced by the French system of "indicative planning". The point to be emphasized is that efficient management of Canada's water resources will increase directly with increases in the quantity and quality of information about the future economic environment. The water service demand studies discussed in the following section pre-suppose the existence of such base studies.<sup>28</sup>

### Water Service Demand Studies

Water is not a single commodity; it is many. Water-derived

services take many forms. These services may be divided into several broad classes. For each class a number of types of study will help to illuminate the factors underlying the demands. The section suggests research efforts necessary to develop demand functions for the various classes of water-derived services.

The point of departure for estimating benefits from a possible water resources development is the demands for the water-derived services to be provided by such development.<sup>29</sup> Obviously, the estimation of benefits can be no better than the quality of the demand functions. It is essential that competent demand studies for water-based services should precede the evaluation of benefits and costs for specific projects. Water demand studies should be initiated in all parts of Canada and they should be maintained up to date as underlying economic forces change.

#### Industrial Use

Descriptive inventories of regional industrial water use are needed for each region in the country. The purpose of such inventories would be to determine the current regional water utilization patterns. Water usage should be classified by quantity and quality of industrial withdrawal, consumption, recirculation, and return flow. The data should be further classified by type of industry, size, technology, climate, cost of water quantity and quality, and by type of usage. Once collected, the data should be recorded on a machine-processable medium so that the inventory can be updated as required.<sup>30</sup>

It is necessary to know how water is currently being used, but this is hardly sufficient for the estimation of industrial water demand in the various economic regions of Canada. Analytical studies of industrial water use are also necessary. Industrial location decisions need

to be studied to determine their sensitivity to water availability and cost. Analysis is required of technical substitution possibilities of other inputs for quantity and quality of water. Such analysis should facilitate estimation of price elasticity of the various types of industrial demand for water withdrawn and discharged. For planning purposes, studies should be made of future technology to determine the probable impact on water demand and the possible returns to research and development of water-conserving technology.<sup>31</sup>

Pioneering research has indicated that the quantity and quality of water used in some industries is extremely sensitive to the cost of supply. The marginal cost of re-cycling waste water operates as a ceiling on the prices that industrial firms will pay for water, i.e., a ceiling on the value of water to industry. But, because water has been so cheap and in such large supply, industrial intake has been very large and re-cycling relatively small. Research has indicated that east coast industries in the United States which use large amounts of water have a large under-developed capacity for economies of water intake in terms of physical quantities.<sup>32</sup> These pioneering studies should be extended into the economic regions of Canada.

On the basis of data collected in the descriptive inventories and the results of the analytical studies of industrial water use, industrial water demand functions should be developed. These should be multi-variate demand functions by region relating industrial water service demands to significant determining variables. The demand functions should incorporate anticipated changes in the industrial development of the regions as provided by the economic base studies.<sup>33</sup>



### Residential Use

Descriptive inventories of current residential water use in Canada are needed. The quantity and quality of regional residential water withdrawal, recirculation, and discharge should be classified by community population size and density, by disposable personal income, by the price of water services, by climate, and other significant variables. The experience gained by the residential water use research project conducted by the Johns Hopkins University will be particularly valuable in this connection.<sup>34</sup>

Analytical studies of migration patterns should be made to determine their sensitivity to water availability and cost. Analysis is needed of price and income elasticities of residential demand for water services. Future technological possibilities and their potential impact on residential water consumption should be examined.

Multi-variate demand functions of residential water consumption should be developed by regions (communities). They should relate residential water service demands to significant determining variables.<sup>35</sup>

### Agricultural Use

Descriptive inventories should be compiled and maintained of regional agricultural water use. Classifications should be made by purpose of use, source of supply, cost of water, type and value of agricultural output produced, amounts and costs of other inputs used (labour, capital, materials), crop yields, etc.<sup>36</sup>

The data base provided by the descriptive inventories of regional agricultural water use should provide a foundation for analytical

studies of that use. Each agricultural region of Canada needs agricultural production functions which will reveal the marginal physical product of water in agriculture. These functions should facilitate studies of the elasticity of substitution of other inputs for water. Future agricultural technology and its potential impact on these elasticities should be studied.

Analysis of world supply and demand for food and fibre should be made to facilitate estimation of the future social value of Canadian agricultural output. On the basis of these studies, alternative regional agricultural output targets should be experimentally established. Analysis should then aim to reveal the least cost ways of meeting those targets under alternative assumptions about the availability and costs of water.

Estimates of future demands for agricultural products should be combined with regional agricultural production functions. Studies of the least cost ways of agricultural production should make possible the development of agricultural water demand functions. These multi-variate functions, differentiated by region, should relate agricultural water service demands to such significant determining variables as the price of various agricultural products, the costs of water and the costs of other inputs.

#### Hydro-electric Power

Descriptive inventories are needed of hydro-electric power production and use. Technological and cost studies should reveal the least cost means of generating electric power in the various regions of the country.

Hydro-electric demand functions should be developed which

relate demand to price of power, regional economic and demographic development, technological change, costs of long distance power transmission, and the cost of electricity production by alternative means.<sup>37</sup>

### Recreational Use

With increased leisure and disposable personal income, the demand for recreation in North America is rapidly expanding. Canada has rich resources for water-based recreation. Descriptive inventories of the present use of these resources are needed. The data should be classified by type and extent of use, by user cost including distance travelled, length of stay, and by the quantity and quality of water required.<sup>38</sup>

Surprisingly little is known of the relationships among public recreation demand and population, disposable personal income, income distribution, amount of leisure time, costs of recreational services, the types of recreation chosen, etc. Studies of these relationships should shed light on the rates of substitution among the various forms of recreation. Studies are needed of the cost of providing non-water-based recreation in the future; these should take account of projected transportation services and costs.

Water-based recreation demand functions should relate regional demand to relevant variables including the cost and availability of recreation elsewhere. The development of such demand functions is relatively uncharted terrain and much theoretical and empirical work remains to be done.<sup>39</sup>



### Inland Navigation

Descriptive studies are needed of the nature and extent of inland navigation in Canada.

Analytical studies should be made of the costs of transportation by inland navigation. Cost studies should be made of alternative transportation modes. The research should investigate the possible directions of technological change as these may impinge upon the costs of alternative forms of transportation. On the basis of these studies, research should examine the least cost methods of meeting alternative possible future transportation needs under alternative assumptions about technological progress.

The ultimate result of analyzing the demand for transportation services and the costs of various modes of providing those services should be the production of inland navigation demand functions by regions in Canada.<sup>40</sup>

### Flood Damage Control

Descriptive studies are needed of flood plain inundation, settlement, and flood losses. Such descriptive studies should capture information about the nature and extent of existing channel improvement, flood proofing, and land use control.

Analytical studies should be undertaken of industrial, agricultural, and population location and investment decisions in flood plains.<sup>41</sup> The decision-making process should be examined under alternative probabilities of flooding and alternative compulsory insurance rates. For various postulated levels of flood damage control, analysis

should be made of the probable effectiveness of alternative strategies for achieving this control. The objective should be to identify the costs and performance of the alternative strategies.<sup>42</sup>

### Histories, Case Studies, and Post-Mortems

Any management system with inadequate feedback is likely to work poorly. To implement feedback in a management system, a method must be created whereby discrepancies between planned and actual results of decisions are noted and proper conclusions about future decision-making are drawn. To say that a management system should have feedback is to say nothing more than that the lessons of experience should be learned.

The studies suggested below are designed to provide feedback on decision-making processes in water management systems. Histories or post-mortem studies of actual water management decisions are needed to determine how good those decisions appear in retrospect. The studies should aim to compare the planned costs and benefits of water management measures with those actually realized.

Post-mortems are a delicate kind of study. The omniscience of important public figures may be placed in the dock. Moreover, great care must be exercised in selecting information for the ex post evaluation. Fools become wise men with the gift of hindsight. It should be remembered that management decisions on major water resource development projects were, by necessity, made without the benefits of hindsight. No amount of effort could have provided as much information to the decision-makers ex ante as will be available to the critic ex post.

The critic is obliged to evaluate the decision-making process which generated any given water resource development in the light of the information that was or could have been available to the decision-makers at the time the decision was made. For example, an event which careful ex ante study revealed to be unlikely might, in the course of time, actually occur. If it did occur, the decisions taken on the estimate of that event's improbability might appear very bad in retrospect. But the careful critic might conscientiously conclude that the decision-making process was not at fault; fickle fortune often leads awry the best made plans.<sup>43</sup>

A second purpose of histories, case studies, and post-mortems should be to evaluate the adequacies of institutions, laws, etc. in water management systems. Careful marshalling of evidence from such ex post studies will strengthen the case for institutional rationalization.<sup>44</sup>

A third type of ex post studies may be termed "impact studies". Experience gleaned from existing water development projects may illuminate the impact of those projects on the economic and ecological environment. At a time when large scale water diversion projects are under consideration, it is highly pertinent to examine the impact of water diversion on the exporting watershed. Such studies should be undertaken in Canada immediately. If Canadian experience in large scale water diversion projects is meagre, these studies could investigate foreign experience.<sup>45</sup>

Impact studies are needed to determine the effect of water shortage on community economic and demographic development.<sup>46</sup> It is important to learn more of the impact of flood control measures on



land values in flood plains.<sup>47</sup> The secondary economic impact of water resource developments is a topic worthy of serious study. Other impact studies could analyze the relationship between upland land management practices and stream flow, and on the relationship between water impoundment and wild life growth.<sup>48</sup>

The informational background for water resource management and system design will be greatly enriched as base studies and demand studies are produced. Additional contribution to this background can be made by the "feedback" provided by the empirical investigations suggested in this section.

#### Water Resource System Planning

The purpose of this section is to sketch the research steps necessary to undertake comprehensive water resource system planning. The studies indicated here should take place against the informational background provided by the regional economic base studies, the water service demand studies, and the "feedback" and impact studies outlined in earlier sections.

One of the most important developments in the water resources management field during the past two decades has been the improvement in water resource system planning. This remarkable development has seen the disciplines of engineering, hydrology, economics and other social sciences joined in searching for better ways to plan and operate water management systems. Various academic programmes have greatly contributed to this cross disciplinary approach in water resources research.<sup>49</sup>

A first step in water resource systems planning is the establishment of planning objectives. To prepare plans, it is necessary to have workable design criteria; these, in turn, require clearly specified objectives. Well formulated and unambiguous objectives, therefore, are the foundation on which the whole water resource system planning effort must rest.

To formulate objectives, policy-makers need the kinds of information outlined earlier in this chapter. But information alone is not sufficient. The governmental policy-making process must have the ability to use this information to arrive at the necessary objectives. The research efforts of political scientists and students of public administration should focus on the problem of improving the method whereby governmental policy-makers develop and specify objectives for public undertakings such as water resource systems.<sup>50</sup>

Various factors beyond the control of water systems planners and policy-makers may influence the feasibility of certain alternatives. Economists attempt to distinguish between these "constraints" and the items that appear as arguments in the objective function. It is less customary for policy-makers to make this distinction since some "objectives" may be formulated in a way so as to constrain the decisions and plans of the water resource systems planners. Nonetheless it is important for planners to recognize the difference between constraints which flow from policy (e.g., concerning income re-distribution), constraints which reflect the dictates of nature or other forces beyond the control of decision-makers at any level, and objectives whose achievement is to be maximized.<sup>51</sup>

After objectives and constraints have been specified, these must be translated into design criteria. At this stage it is necessary to specify the planning region and the scope of the water resource planning effort. Canadian economists, geographers, and political scientists should help to determine the appropriate regions for water resource planning. The water resource planning effort must relate to the demographic and economic plans and projections discussed earlier. It is quite impossible to specify optimal design criteria without taking into consideration the planned and projected development of the economy and other factors such as transportation planning, recreation development, land use planning, etc. Research is necessary to perfect ways of combining the technological, economic, social and institutional factors into meaningful design criteria.

After concrete design criteria have been developed, the water resource systems design effort may begin. At this stage it is vital to consider a wide range of alternative structural and non-structural components of the system.~ Alternative mixes of water-derived services should be considered and evaluated. At this stage it is necessary to estimate the probable benefits resulting from these alternative mixes. Such estimation should be based on the regional economic and demographic base studies and the water service demand studies discussed earlier. Although much progress has been made recently in benefit estimation, much more work remains to be done in this field.<sup>53</sup>

In order to study the dynamic behavioural characteristics of alternative system designs, it is highly desirable to have models that reflect the stochastic aspects of stream flow and the complex physical and economic interactions of multi-unit, multi-purpose systems.



These models should incorporate the behavioural characteristics of water service users as expressed in the demand functions and other relationships that may be derived. Computer simulation is a powerful method of building such complex models. Such a building task requires the collaboration of hydrologists, engineers, economists, operations researchers, computer scientists, and applied mathematicians.<sup>54</sup>

The last fifteen years have brought much progress in the methodology of building complex system simulation models.<sup>55</sup> Much more research remains to be done to perfect these models as experimental tools for water resource management. Models are still developed specifically for each system design effort. This "custom made" approach is expensive and time consuming. Research is needed to develop flexible water resource simulation languages or digital computers.

The system simulation model should be used as an experimental vehicle to study the costs and benefits of alternative system designs. Such a vehicle permits the examination of many more structural and non-structural system design features than is possible without the use of digital simulation. Because more alternatives can be evaluated, the design of optimal systems features is facilitated. But since a simulation model can consider so many alternatives, more research is needed to develop better algorithms for improving the search for optima.

After thorough and careful evaluation of pertinent alternatives has led to what appears to be good system design, studies should be made of the implications of relaxing constraints. This is particularly pertinent to those constraints imposed by policy and institutional structure.

The "shadow prices" of these constraints should be evaluated and policy-makers should be apprised of the costs of maintaining those constraints unaltered. Frequently policy-makers impose constraints on the decision-making process in the absence of full information about their "shadow prices". Before final imposition of the constraints, policy-makers should be provided with this information and with any recommendations for altering policy and institutional constraints.<sup>56</sup>

### Priorities and the Means of Accomplishing the Research

It is difficult to specify the priorities which should be attached to research on the various research topics described in this chapter. Major progress in any one of them would make an important contribution to more efficient resource allocation in water systems management. Nevertheless, if three topics were to be singled out from the rest as deserving special emphasis and support, the primary candidates would be: (1) Demographic and economic base studies; (2) Industrial, residential, and agricultural water-service demand studies; and (3) Digital simulation models for complex systems analysis.

In science there should be strong interaction between empirical analysis and practical problem solving on the one hand and the development of theory on the other. Necessity is often the mother of invention in science just as it is elsewhere. The strategy of research support should take account of this. The theorist working in isolation from empirical reality is likely to produce errored or irrelevant theory. The practitioner who is uninterested in conceptualization and theory can make little progress in perfecting the methodology of his work. For these reasons, it is desirable to seek extensions of theory and the

solution of practical problems in one and the same study. Although topics of theoretical research have been separated in the above discussion from those of a more applied nature, there is every reason to expect that the two should progress simultaneously.

It is my opinion that investment in theoretical research will reap its greatest dividends if it supports the work of scientists strongly interested in improving the theory and methodology of decision-making and who accept the field of water resources management as a testing ground for the development of their ideas.

Canada has many competent economists, operations researchers, mathematicians, and computer scientists who would be capable of making important contributions to the topics mentioned in the preceding sections. But it is necessary to turn their interests and attention to those topics and to support their research.

At both the provincial and federal levels of government there are economists working in government agencies who could assume much of the burden for producing the economic base studies. Such base studies are perhaps less "research" than they are "development" because they are based on existing economics methodology. The important point to be stressed is that these studies are vitally necessary to the development of the water-services demand functions recommended above.

The methodology of water-services demand function estimation is much less developed than that for economic base studies. Much basic research and experimentation remains to be done and it is desirable



to attract to this research the talents of imaginative economists working in the government service and universities. Many Canadian universities have staff members who, if their talents were so directed, could contribute measurably to progress in this field. Graduate students working on theses and dissertations could benefit themselves and the field of water resources management if they were to select topics from this area for their research.

The design and use of digital simulation models is a very young art. The technique holds great promise for water resources management because it creates the analogue of a laboratory in which alternative system designs may be tested and evaluated. Research work, especially in the universities, should be energetically supported.

In selecting research projects for financial support, it seems unwise to confine the view only to members of water resource research centres. Economists and other scientists capable of making major contributions can be found in every province of Canada; those with a theoretical bent will often not have affiliated themselves with a centre or institute oriented toward research in any specific empirical field. If we seek real breakthroughs, some of these people must be attracted to research in the water resource management field. To make financial support for their research contingent upon membership in a water resources research institute would therefore be unwise.

It is my opinion that the major constraint hindering the needed increase of research efforts in the water resources management field is financial. Many economists and other scientists of high calibre are available in Canada. I firmly believe that a substantial number of

these would be prepared to devote their talents and energies to research in this field if adequate financial support were made available. Judging from what we know about the kinds of problems that presently occupy the attention of many economists, it is apparent that the real opportunity cost of diverting those attentions into research in water resources management would not be excessively high.

## FOOTNOTES

I am indebted to W.R. Derrick Sewell for valuable assistance on the first part of this chapter. My colleagues John Dales and Ian Burton helped me to learn more about the economics of water resources. Remaining errors in the chapter, alas, are my own.

1. The only articles to appear in the Canadian Journal of Economics and Political Science in the period 1908 to 1968 that deal directly with water resources were J.C. Bonbright, "Power Aspects of the St. Lawrence Waterway," Vol. 8, 1942, pp. 176-185; and Clarence Barber, "Water Resource Development," Vol. 27, 1961, pp. 533-540. There were a few others that dealt with related matters, notably A.D. Scott, "Resourcefulness and Responsibility," Vol. 24, 1958, pp. 203-215; G.K. Goundry, "Economics and Conservation," Vol. 26, 1960, pp. 319-325; James M. Buchanan, "Simple Majority Voting, Game Theory and Resource Use," Vol. 27, 1961, pp. 337-348; and Richard L. Gordon, "Conservation and the Theory of Exhaustible Resources," Vol. 32, 1966, pp. 319-326. Even when these latter contributions are considered, however, the total number is still very small. Harry G. Johnson, in his review of Canadian economic research since 1945 notes that a number of Canadian economists have made valuable contributions to the development of theory relating to natural resources management. None of the works he cites, however, deal directly with water resources. See Harry G. Johnson, "Canadian Contributions to the Discipline of Economics since 1945," The Canadian Journal of Economics, Vol. 1, No. 1 (February, 1968), pp. 129-146. It should be noted, however, that many useful contributions by Canadian economists have appeared in journals other than the Canadian Journal of Economics and Political Science, notably in Land Economics and the Natural Resources Journal.
2. Many of these contributions, however, have been made in journals other than the principal Canadian economic journals, and principally in journals of the United States. Many useful papers have been contributed to major resource conferences, such as the Resources for Tomorrow Conference and the National Conference on Pollution and Our Environment.
3. J.P. Bruce and D. Maasland, Water Resources Research in Canada, Science Secretariat, Privy Council, Ottawa: Queen's Printer, 1968, p. 47.



4. See, for example, A.D. Scott, "Allocation of Resources to Future Uses and Related Public Policy," in Canadian Economic Policy, T.N. Brewis et al (Eds.), Toronto: Macmillan Co., 1961, pp. 94-142; P.H. Pearse, "Public Management and Mismanagement of Natural Resources in Canada," Queen's Quarterly, Vol. 73, No. 1 (Spring, 1966), pp. 86-99; and W.R. Derrick Sewell, "A Continental Water System: Pipedream or Practical Possibility?" Bulletin of the Atomic Scientists, September, 1967, pp. 9-13.
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## CHAPTER 3

### GEOGRAPHICAL RESEARCH IN WATER MANAGEMENT IN CANADA: INVENTORY AND PROSPECT

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#### The Past Record

The development and use of natural resources have provided a major focus for geographical enquiry in several parts of the world. Some valuable contributions have been made both to the fund of knowledge and to theory in this connection, particularly in the field of water resources.<sup>1</sup> In Canada geographical research relating to water resources was tended to concentrate on three main lines of enquiry: factors affecting the distribution of these resources, the development of water resources in particular regions, and the influence of various institutional factors in decision-making.<sup>2</sup>

The distribution of water resources is affected by a wide variety of physical factors, including climate, terrain, and geology. Such factors have received considerable attention by Canadian geographers, and some important contributions have been made to the literature in this connection, as is noted in recent reviews.<sup>3</sup> Although only a few of the studies have been undertaken with water resource



development in mind, many of them have provided material that has potential value in this regard. Thus far the principal concentration has been on the Canadian North,<sup>4</sup> the St. Lawrence and the Great Lakes,<sup>5</sup> but interest in other regions is now growing. At the same time Canadian geographers are making some important contributions to research on hydrology<sup>6</sup> and to techniques of identification and measurement of physical phenomena, such as subsurface water flows.<sup>7</sup>

A second focus of geographical research has been on the development of water resources in particular regions. Here again the principal emphasis has been upon the St. Lawrence-Great Lakes drainage system and the Mackenzie River.<sup>8</sup> This concentration reflects a recognition of the focal point of Canadian economic activity on the one hand, and the Canadian geographer's interest in the North on the other. Particular attention has been given to the St. Lawrence Seaway and its contribution to the economic growth of the Great Lakes region and to the nation as a whole.<sup>9</sup> Other studies have dealt with the development of hydro-electric power,<sup>10</sup> and with floods<sup>11</sup> in various parts of the country. Most of the earlier studies were descriptive accounts and used relatively simple tools of analysis. Few of them added to theory. More recent contributions have reached higher levels of sophistication, particularly through the use of quantitative methods of statistical analysis and economic analysis. A number of Canadian geographers have assisted in the improvement and adaptation of methods for use in the appraisal of water resource development projects.<sup>12</sup>

The third type of study relates to the influence of various institutional factors in decision-making relating to water management.

Important among such factors are problems resulting from divided jurisdiction, administrative arrangements, and legal constraints. Geographers have examined the influence of these factors on river basin planning in various parts of Canada,<sup>13</sup> notably in Ontario,<sup>14</sup> the Prairie Provinces,<sup>15</sup> in B.C.<sup>16</sup> and in the Territories.<sup>17</sup> Most of these studies have been undertaken in the past five years, reflecting a growing interest among Canadian geographers in policy questions.

The foregoing review indicates that Canadian geographers have made some important contributions to water resources planning and development. It also shows that there have been some significant shifts in the focus of geographical research in the water resources field in recent years. There has been a change in emphasis on physical aspects of water management to economic, social and political aspects. This has been accompanied by increasing use of more sophisticated tools of analysis, and by a growing interest in public policy questions in the resources field.

Important as the past contributions of Canadian geographical research to water management have been, they have been small, when judged either against the seriousness of the problems to be solved or against what has been contributed by geographers elsewhere. Many questions which would seem to be of obvious interest to geographers have not attracted the attention of Canadian geographers. The proportion of water resource geographers in the United States and the Soviet Union is much higher than it is in Canada. There are several possible explanations for this situation and these are noted later. The important thing to notice, however, is that interest among Canadian geographers

in water problems has increased rapidly during the past five years. Several Geography Departments at Universities in different parts of the country have appointed new faculty members offering a specialization in this field. Graduate programs in geography have also begun to include water resources as a major topic for study.

### New Horizons for Geographical Research

Given the increasing interest and capability of geographers in the field of water resources, what are the types of research that they might usefully undertake in the search for solutions to the emerging problems of water management in Canada? Taking account of the kinds of studies that have been undertaken by geographers in Canada and elsewhere in the water field directly and in cognate fields, four major types of study suggest themselves. These are concerned with estimating the magnitude and possible uses of Canadian water resources; the analysis of spatial impacts of development, the influence of institutional constraints in the formulation and implementation of resource development plans; and the role of perception and attitudes in decision-making.

### Estimating Resources and Resource Uses

Two of the most urgent needs in Canada are an estimate of available water resources and an estimate of the demands that are likely to be placed on these resources within the next twenty or thirty years. Without such estimates it is impossible to formulate policies relating to the allocation of water between competing users or policies relating to the export of water to the United States. A wide variety of methods are required in deriving such estimates, both methodological and empirical. Methodologies for estimating the magnitude of water



supplies are fairly sophisticated but those relating to water use are still quite crude. Some important advances have been made in empirical research relating to the factors affecting water supply, but much remains to be learned. With such a vast territory to be covered and so few workers engaged in research on such matters, the task is truly an enormous one. Empirical research relating to water use in Canada has also been quite limited.

Among the various studies which geographers might undertake to assist in the derivation of better estimates of Canadian water supplies and water demands, four would be especially valuable. One type concerns the development of water balance estimates, taking into account such factors as precipitation, evapotranspiration, temperature, soil moisture storage, and ground water recharge. Application and refinement of methodologies developed by Thornthwaite and Mather,<sup>18</sup> for example, could contribute a great deal in this connection. Another type of investigation would be concerned with hydrographic mapping, and with the identification and mapping of areas subject to floods and droughts. Such identification would be assisted by the development and use of synthetic estimates.<sup>19</sup> A third type of study would focus upon land use capabilities, taking into account not only physical potentials but economic, social, and other considerations as well. Such studies would not be mere accumulations of information as many land use inventories have been in the past but would be organized in such a way that the data collected would be useful in the actual planning and implementation processes. The information would be classified into meaningful categories and stored in such a manner that retrieval would be simple.<sup>20</sup>

A fourth line of enquiry would be the investigation of water use in various areas, aiming to improve methodologies on the one hand and to develop synthetic estimates on the other. A number of geographers have undertaken studies of water use by particular industries in selected areas.<sup>21</sup> There have also been a few studies of water use by industry as a whole,<sup>22</sup> and by non-industrial users.<sup>23</sup> Many of these, however, have employed fairly simple methods and there has been little attempt to identify the factors which account for the large variations in use that occur between individuals or between regions. Some important improvements have been made in methodologies in recent years and geographers should now apply them to studies of water use in different regions.

#### Analysis of Spatial Impacts of Development

One of the most important characteristics of water resource development is that it has "external effects". Such effects include those which are imposed upon alternative uses at the point where the water development occurs (such as at a dam site) and those which occur somewhere else in the river basin (such as downstream from the dam). They may be purely physical in character (such as in the alteration of streamflow patterns within the basin) but more often they have economic and social consequences as well. External effects are among the most important causes of disputes in water management. But they can be beneficial too. In fact, their existence provides the driving force behind many proposals for water development, as in the case of proposals for upstream storage. Because of the potential beneficial and/or adverse external effects it is important that they be properly identified, measured, and weighed along with other con-

siderations in decisions about water development projects. Geographers can make many useful contributions to research in this connection.

On the physical side, geographers might investigate the effects on downstream flow and sediment load when discharge upstream is modified, such as through storage or diversion. A number of French geographers have undertaken valuable studies on such effects. In the United States several geographers have examined the physical downstream effects of upstream reservoir construction. Such impacts provide numerous opportunities for geomorphological research. There are other external effects too, notably those on plant and animal communities. Studies of these impacts furnish avenues of fruitful research for biogeographers.

Geographers can also contribute to the identification and measurement of external economic effects of water development. A number of useful studies have been undertaken already in this connection, including those relating to the identification of indirect benefits or irrigation projects,<sup>24</sup> the effects of dam construction on fishery resources,<sup>25</sup> and the effects of waste disposal on other water uses.<sup>26</sup> These have contributed both to theory and to public policy. Further empirical investigations of economic impacts beyond the water development project would be extremely useful to decision-makers in the resource management field. Investigations of potential external economic effects of different policies for solving particular problems should also be undertaken. For example, studies of the effects of the construction of a hydro-electric power dam versus the construction of a thermal power station might be a valuable input into the choice



between the two. Similarly, studies of the effects of diverting water from one watershed to another as against the effects of making better use of existing supplies should be assessed in economic, social, and political terms.

In undertaking these studies geographers might usefully combine their interest in spatial variation with the concepts and techniques of other disciplines, such as those in economics and statistics.<sup>27</sup> A number of studies of spatial impacts of alternative schemes of river management have been undertaken, using sophisticated techniques of analysis such as simulation and systems analysis.<sup>28</sup> More of these studies are needed. The techniques also need to be refined to permit more precise measurement of impacts.

Another type of study in this connection is concerned with the relationship between water resource development and economic growth. Observation of a number of regions in which large investments have been made in such development seems to suggest that it provides a trigger to economic growth.<sup>29</sup> But the precise nature of the relationship is not well understood.<sup>30</sup> Much further study is required to determine how much of the development is due to the initial investment in water projects and how much is due to other factors. Research also needs to be undertaken to determine the stage of economic growth where such investment yields the most widespread economic effects.

Studies of external social and political impacts are also required. Policy makers need to know, for example, what the effects of a proposed irrigation scheme are likely to be on the social structure

of the communities in the region affected by the scheme. They also need to know whether it will create adverse reaction from adjacent areas. Such problems should provide grist for the mill both of the social geographer and the political geographer.

### The Influence of Institutional Constraints

Resource management takes place within a framework of social guides which either encourage or discourage certain kinds of action being taken. Such guides include customs, mores, attitudes, laws, policies, and organizations of various types, such as administrative agencies and pressure groups. Knowledge of the influence of these social guides is essential if resources planning is to be effective in attaining its objectives. Numerous examples could be cited of resource development projects that have failed to attain the objectives specified for them, because those who planned them failed to take into account the probable public reaction to them or the capacity of the existing administrative arrangements to implement them.<sup>31</sup> Flood control schemes have often failed to reduce flood losses because resource managers have not taken into account the fact that construction of flood protection works tends to stimulate further occupancy of the flood plain.<sup>32</sup> Irrigation schemes have sometimes failed to obtain support from farmers for whom the projects were built, possibly because the planners did not attempt to determine beforehand whether the farmers in question were willing to change their farming methods. As yet the influence of social guides has been investigated to only a minor degree. Much useful research could be done in this connection.

Among the types of study relating to social guides that might be undertaken, one of the most valuable would be the hindsight examination of resource development projects and policies. Most projects have fairly well defined economic or social objectives, such as increasing regional income, fostering change in agricultural practices, or reducing flood losses. It is rare, however, to find any attempt to determine whether these objectives have in fact been attained, and if they have not, the reasons that might account for this. It would be extremely valuable, for example, to look back in a few years' time and determine the extent to which the South Saskatchewan Project has succeeded in reducing the flood loss potential. It would also be instructive to examine the effectiveness of various resource management policies, such as those embodied in Canada Water Conservation Assistance Act or in the Prairie Farm Rehabilitation Act.

Another extremely useful avenue of research would be the examination of the effectiveness of various types of administrative devices in managing water resources in different parts of the country. Water Resources Commissions have been set up in several provinces. Have they been more effective in some provinces than in others? The Conservation Authority appears to have had some success in Ontario but has not been adopted elsewhere. Are the conditions in Ontario more favorable for the establishment of such a device in that province than in others? The Prairie Provinces Water Board was set up with two major objectives: one, to allocate water between the member provinces, and two, to determine the best use of the available resources. The Board carried out the first function and undertook a number of useful studies but it never undertook any investigations to enable it to



perform the second function. What can be learned from the experiences of the Board that would be useful in other cases? The Fraser River Board studied the flood problem in the Lower Fraser Valley and after fourteen years of investigations recommended a scheme of hydro-electric power development and flood control.<sup>33</sup> Some four years after the presentation of the report the scheme has still to be implemented. Similarly, the Red River Investigation of the Winnipeg Flood Problem was completed in 1957 but did not result in any action until 1962.<sup>34</sup> In what circumstances is the engineering board likely to be a successful planning device and in which instances is it likely to be ineffective? Studies of various types of administrative and planning structures in different parts of the country would clearly be an invaluable input into water resources policy-making in Canada.

#### The Role of Perceptions and Attitudes

Studies by geographers and others have shown that perceptions of water problems and potential solutions<sup>35</sup> and attitudes as to who is responsible and as to what ought to be done about such problems,<sup>36</sup> condition to an important extent decisions in the water management field. Some pioneering work in determining the role of perception in decision-making has been undertaken in connection with adjustment to floods<sup>37</sup> and droughts,<sup>38</sup> and in connection with the use of recreational areas.<sup>39</sup> Studies relating to the role of attitudes have also been carried out in connection with pollution<sup>40</sup> and weather modification.<sup>41</sup> Such investigations, however, have been few in number and much remains to be learned about the factors which condition perception and attitudes, and the extent to which the latter vary from one set of geographical circumstances to another. The relative importance of perception and

attitudes in decisions about different water problems is still unknown. Do attitudes towards responsibility for initiating action play a greater role, for example, in the case of pollution than they do in the case of domestic water supply? Greater understanding of perceptions and attitudes would make possible improvements in policy-making and implementation, for it would permit the prediction of likely reactions to various alternative courses of action. Research in this connection, therefore, is likely to have a very high payoff, not only in terms of increasing understanding of human behaviour, but also in terms of improving decision-making.

Among the various types of studies that are needed in this connection, the following seem to be of particular urgency: in what ways do people perceive particular water problems (such as floods, droughts, or pollution) and what do they see as potential solutions (in the case of floods, do they see flood plain regulation, flood proofing, and flood insurance as well as flood control works, evacuation, and compensation?); do the perceptions of the layman differ significantly from those of the specialist; how do attitudes about the nature of the problem, who should initiate action, and what should be done, affect actual decisions; are there major differences in attitudes between the various groups that participate in the decision-making process (individuals, pressure groups, industrialists, administrators, and politicians); in what ways can attitudes be changed; and, most importantly, how do perceptions and attitudes vary from one place to another?

### Implementation of the Needed Research

The foregoing list of research topics has been highly selective and does not by any means cover the full range of potential avenues of geographical enquiry in the water resources field. Judged in terms of the past record, and in terms of present availability of funds and personnel, however, the list is a very formidable one. To implement it would require some major changes in present funding mechanisms, and in training programmes at the universities.

At present expenditures on social science research in the water resources field in Canada amounts to less than \$250,000 a year. Of this, some \$60,000 a year is devoted to studies undertaken by geographers.<sup>42</sup> There are several possible explanations for the small magnitude of these funds. One is that expenditures on social science research as a whole in Canada are extremely small, amounting to less than two million dollars a year or less than one per cent of the funds spent on all scientific activity in the country. Another is that very few Canadian geographers have been interested in water resources problems, and particularly the public policy aspects of such problems. Of the 150 or so professional geographers in Canada, probably no more than half a dozen have made continuing contributions to water resources research. A third possible explanation is that programmes of graduate training in Canadian universities have only recently begun to offer courses in water resources management. The lack of such courses in the past has inevitably meant that the supply of resource geographers in Canada has been small. Most of those who have been interested in this field have had to go to the United States for graduate training and many of them have not returned to Canada, partly because of the



greater availability of research funds there but also because of the lack of job opportunities here. Water management agencies have tended to be staffed almost entirely by engineers.

During the past five years, however, some important developments have occurred which have improved the prospects for employment of geographers and for the expansion of geographical research. First, the federal government and several provincial government agencies have broadened their view of the potential contribution of geographers to policy formulation and implementation. Until its recent demise, the Geographical Branch was almost the only source of employment of geographers in the federal civil service. The Branch, however, was not very interested in resource problems or in public policy questions, and it was seldom called upon for advice on these matters. Elsewhere in the federal civil service, and in most provincial government agencies, geographers have been employed mostly on cartographic work and in providing data about economic activities in various regions of the country.

Recently, however, a number of federal agencies have begun to employ geographers in policy-making and policy implementation, and for undertaking related research. The Department of Energy, Mines and Resources, in particular, has recognized the potential contribution of geographers in this connection, and especially those with a competence in the resources field, and now employs several of them. The Department has established an Economic Geography division which will be undertaking research into resources management problems, as well as other problems. In addition, it has substantially

increased the funding of geographical research through the National Advisory Committee on Geographical Research. A number of provincial government agencies have also begun to employ geographers for a broadening range of tasks. There is an increasing demand for personnel with a competence in the resources field, particularly among water resources agencies and recreation agencies. In addition, employment opportunities for resource geographers are increasing in industry, particularly in the oil industry.

Second, there has been a gradual increase in the amount of money available for research in the water resources field, not only for the investigation of physical aspects but also for the study of human dimensions. This increase has been stimulated in part by the International Hydrological Decade (IHD) and by a growing recognition of the water management problems that are now being faced by the nation. Until relatively recently most of the research funds available for water studies were provided by agencies whose interests were dominantly focussed upon physical aspects.<sup>41</sup> Today, however, not only have these agencies adopted much broader views,<sup>45</sup> but agencies which have traditionally funded social science research have shown increasing interest in studies relating to water management.<sup>46</sup> During the past year a most important development occurred which is likely to lead to a major increase in social science research relating to water management. The Department of Energy, Mines and Resources established a National Advisory Committee on Water Resources Research and provided it with \$250,000 for studies in the social sciences, as well as \$250,000 for research in the physical sciences. In addition to its programme of grants to individual researchers, the committee

is also initiating a programme of Development Grants, aimed at providing support for water resources research centers in various parts of the country.

A third change is the development of resource geography programmes at more than a dozen universities across Canada, some of which extend to the graduate level. Such a development has increased the availability of potential researchers in the field and has provided an incentive for graduate students to remain in Canada for training in this connection rather than to go to the United States.

Important as these changes have been, they are clearly only a beginning. Further modifications of existing policies and programmes will be required if the needed geographical research is to be undertaken. A much larger allocation of funds for such research is urgently required. It is evident that Canadian geographers are now ready, willing and able to expand their efforts in the field of water resource studies. Increasing the amount of funds will not only enable more work to be done but will also stimulate researchers in cognate branches of geography, such as political geography, biogeography, or urban geography, to examine water resource questions. Part of the additional funds should be spent on developing training programmes, for it is only in this way that increasing numbers of researchers will be made available. In addition, a much broader view of funding must be taken in the social science field than has been the case to date, providing long term grants as well as annual grants. Grants for a two or three year period are common in the physical sciences but rare in the social sciences. The annual basis of grants in the latter has doubt-



less limited the pace as well as the scope of research. Funds should also be provided for inter-disciplinary research programmes. At present no convenient mechanism exists for the funding of such programmes. The Canada Council and the National Research Council should consider the establishment of a special joint committee to screen applications for inter-disciplinary research support.

Another urgently needed improvement is the establishment of more effective liaison between government agencies and the universities and between industries and universities. Such liaison has been generally lacking in Canada thus far.<sup>47</sup> A consequence has been to severely limit the contribution of universities in the water management field, both in terms of the provision of personnel required by government agencies and industries and in terms of research output. University professors have often remained merely critics of policy rather than as contributors to its improvement.

There are several ways in which liaison might be improved. One would be for government agencies and industries to discuss problems of resources management with university professors more frequently than has been the case in the past. This might be accomplished by the establishment of advisory committees on water policy at the federal level and the provincial level, composed of government personnel, industry representatives and university professors. Liaison could also be improved by increasing the opportunities for university personnel to work on resource management problems in government agencies for a period of several months, and for representatives of government agencies to participate in resource management courses and seminars at universities.

Liaison also needs to be improved between the various disciplines interested in water problems. Typically researchers in the water management field have worked in isolation from each other. It has become increasingly clear, however, that effective solutions to water problems may require inputs from several disciplines. Mechanisms are required to bring together researchers in the various fields involved. Several possibilities suggest themselves, including the establishment of inter-disciplinary Water Resources Institutes or Centers, and the development of inter-disciplinary training programmes. A successful experiment has been undertaken in this connection at the University of Manitoba in which a water resources center coordinates a broad programme of water resources research, provides a means of bringing together researchers working in a wide variety of disciplines, and maintains effective liaison between the university and various provincial government and federal government agencies and with industry. Proposals have been made for the establishment of Water Resources Centers and Institutes at universities elsewhere in Canada. How many centers or institutes should be set up, however, is an open question. The case for their establishment is most forceful where it is possible to show that they would lead to an improvement in the calibre of research and where the nature of the studies to be undertaken is such that it can benefit substantially from inter-disciplinary contact. There must be close coordination of the efforts of the various centers so as to avoid costly duplication of effort and so as to ensure that the most urgent questions are investigated. Such considerations should be borne in mind in the formulation of federal and provincial policies for funding such centers.

## FOOTNOTES

The author wishes to acknowledge the helpful comments and suggestions of B.H. Farrell, R.W. Robertson and J. Elizabeth McMeiken of the Department of Geography, University of Victoria, in the preparation of this chapter.

1. For a comprehensive review, see Gilbert F. White, "Contributions of Geographical Analysis to River Basin Development," Geographical Journal, Vol. CXXIX, 1963, pp. 412-436.
2. These conclusions are based mainly on a review of contributions to the Canadian Geographer, the Annals of the Association of American Geographers, the Geographical Review, the Geographical Journal, and Economic Geography. Some of the contributions have been made by Canadian geographers and others by non-Canadians who are interested in Canadian problems. The review is incomplete to the extent that it does not include contributions to many journals outside North America, and to the extent that it does not cover contributions of geographers to non-geographical publications. Nevertheless, it is believed to be reasonably representative.
3. Contributions by Canadian geographers to research on physical geography are reviewed in several chapters of John Warkentin (Ed.), Canada: A Geographical Interpretation, Toronto: Methuen Publications, 1967. See also various contributions, particularly on geomorphology and glaciology, published in Canada, Department of Mines and Technical Surveys, Geographical Branch, Geographical Papers, and the Geographical Bulletin.
4. The Mackenzie River, in particular, has received considerable attention. See, for example, J.R. MacKay, "Mackenzie Deltas: A Progress Report," Canadian Geographer, 1956, pp. 1-12; and J.K. Stager, "The Structure of Some Pingos in the Mackenzie Delta Area, N.W.T.," Geographical Bulletin, Vol. 8, No. 4, 1966, pp. 360-368. See also M.C. Marcus, "Periodic Drainage of Tulsequah Lake, B.C.," Geographical Review, 1960, pp. 89-106, and W.E.S. Hencock, "Observations of Mackenzie River Discharge," Canadian Geographer, 1960, pp. 44-50.



5. Studies of the St. Lawrence-Great Lakes drainage system have included Mark Jefferson, "Variations in Lake Huron Levels and the Chicago Drainage Canal," Geographical Review, Vol. 20, 1930, pp. 133-138; Joyce Brown, "The Drainage Pattern of the Lower Ottawa Valley," Canadian Geographer, 1962, pp. 22-31.
6. Recent contributions have included A.H. Laycock, "Water Deficiency and Surplus Patterns in the Prairie Provinces," Prairie Provinces Water Board Report No. 13, Regina, Saskatchewan, 1967. D.R. MacKay, "Characteristics of River Discharge and Runoff in Canada," Geographical Bulletin, Vol. 8, No. 3, 1966, pp. 219-227.
7. See, for example, D.C. Ford, "Sinking Creeks of Mt. Tupper: A Remarkable Groundwater System in Glacier National Park, B.C.," Canadian Geographer, 1967, pp. 49-53, which describes the use of several new techniques for identifying and measuring subsurface flows, such as the use of fluorescene and charcoal indicators.
8. See, for example, W.O. Albright, "Gardens of the Mackenzie," Geographical Review, Vol. 23, 1933, pp. 1-23.
9. Studies of the potential contribution of the St. Lawrence Seaway to the regional and national economy have included Roderic Peattie, "The Resources of the Lower St. Lawrence Valley," Annals of the Association of American Geographers, Vol. 25, 1935, pp. 103-116, and 178-184; C.P. Wright, The St. Lawrence Deep Waterway: A Canadian Appraisal, Toronto: The Macmillan Co., 1935; H.A. Wood, "The St. Lawrence Seaway and Urban Geography, Cornwall to Cardinal, Ontario," Geographical Review, Vol. 45, 1955, pp. 509-530; P. Camu, "The St. Lawrence Seaway from Quebec City to Cornwall," Canadian Geographer, No. 7, 1956, pp. 28-31; and H.A. Wood, "The Influence of the St. Lawrence Seaway upon the Cornwall-Prescott Area, Ontario," Canadian Geographer, No. 7, 1956, pp. 31-35.
10. See, for example, W. McIntyre, "Niagara Falls Power Re-development," Economic Geography, Vol. 28, 1952, p. 261; W.R. Derrick Sewell, "Hydro-electric Power Possibilities in the Yukon River Basin in Canada," Water Power, June, 1964, pp. 259-263, and July, 1964, pp. 306-311; W.R. Derrick Sewell, "Flood Control

- and Hydro-Power Development on the Fraser River," Water Power, June, 1964, pp. 239-240; W.R. Derrick Sewell, "The Role of Regional Inter-ties in Post War Energy Resource Development," Annals of the Association of American Geographers, December, 1964, pp. 566-581; and W.R. Derrick Sewell, "The Columbia River Treaty: Some Lessons and Implications," The Canadian Geographer, September, 1966, pp. 145-156.
11. See, for example, F.A. Kerr, "The Ice Dam and Floods of the Talsekwe," Geographical Review, Vol. 24, 1934, pp. 643-646; G. Nelson and A.R. Byrne, "Man as an Instrument of Landscape Change: Fires, Floods, and National Parks in the Bow River Valley, Alberta," Geographical Review, Vol. 56, 1966, pp. 226-239; Ian Burton, "A Preliminary Report on Flood Damage Reduction," Geographical Bulletin, Vol. 7, No. 3, 1965, pp. 161-185; and W.R. Derrick Sewell, Water Management and Floods in the Fraser River Basin, op. cit.
  12. See, for example, Roy Wolfe, "Recreational Travel--The New Migration," Canadian Geographer, 1966, pp. 1-15; and W.R. Derrick Sewell et al, Guide to Benefit-Cost Analysis, Ottawa: Queen's Printer, 1961. For a review of problems in the application of economic analysis in water resources management in Canada, see Ian Burton, "Investment Choices in Public Resource Development," in The Prospect of Change, A. Rotstein (Ed.), Toronto: McGraw-Hill, 1964.
  13. Reviews of such problems appear in W.R. Derrick Sewell, "Multiple Purpose Development of Canada's Water Resources," Water Power, April, 1962, pp. 146-151; and Allen K. Philbrick, "The Nodal Water Region of North America," Canadian Geographer, Vol. 8, No. 4, 1964, pp. 182-187. For a discussion of international boundary water problems, see S. Whittemore Boggs, "Problems of Water Boundary Definition," Geographical Review, Vol. 27, 1937, pp. 445-455.
  14. See, for example, E.G. Pleva, "Multiple Purpose Land and Water Districts in Ontario," Comparisons in Resource Management, H. Jarrett (Ed.), Baltimore: Johns Hopkins Press, 1961, pp. 189-207; and T. O'Riordan, "A Study of Canadian Multipurpose Water Resources Management--What Britain Can Learn," Journal of the Institution of Water Engineers, Vol. 21, No. 3, 1967, pp. 314-321.

15. See, for example, S. Raby, "Alberta and the Prairie Provinces Water Board," Canadian Geographer, Vol. 8, 1964, pp. 85-92; J.H. Richards, "Provincialism, Regionalism and Federalism as Seen in Joint Resource Development Programmes," Canadian Geographer, 1965, pp. 205-216; Stewart Raby, "Irrigation Development in Alberta," Canadian Geographer, Vol. 9, No. 1, 1965, pp. 31-39.
16. See, for example, W.R. Derrick Sewell, "River Basin Development in B.C.," Water Power, December, 1962, pp. 492-497; and W.R. Derrick Sewell, "The Columbia River Treaty: Some Lessons and Implications," op. cit.
17. See, for example, W.R. Derrick Sewell, "Hydro-electric Power Possibilities in the Yukon River Basin in Canada," op. cit.
18. C.W. Thornthwaite Associates, Average Climatic Water Balance Data of the Continents, Part IV, "North America" (Excluding U.S.) Laboratory of Climatology Publications in Climatology, Vol. XVII, No. 2, 1964.
19. The use of such estimates for estimating areas of potential flooding has been described in G.F. White, Choice of Adjustment to Floods, Chicago: University of Chicago, Department of Geography Research Paper No. 93, 1964, pp. 42-44. For an application to the estimation of flood losses in Canada, see Manitoba Royal Commission on Flood Cost-Benefit, Final Report, Winnipeg, Manitoba: Queen's Printer, 1958.
20. A move in this direction has been made with the establishment of the ARDA Land Use Data Bank.
21. See, for example, Morgan D. Thomas, "Estimates of Water Uses in the Muskingum Watershed Conservation District for 1975," Annals of the Association of American Geographers, Vol. 50, No. 1 (April, 1960), pp. 22-41.
22. See, for example, Gilbert F. White, "Industrial Water Use," Geographical Review, Vol. 50, 1960, pp. 412-430.



23. Such studies include investigations of recreational water use. See, for example, Edward L. Ullman, Ronald R. Boyce, and Donald J. Volk, The Meramec Basin: Water and Economic Development, Meramac Basin Research Project, St. Louis, Mo., 1962; and E.L. Ullman and Donald J. Volk, "An Operational Model for Predicting Reservoir Attendance and Benefits: Implications of a Location Approach to Water Recreation," Papers of the Michigan Academy of Science, Arts and Letters, Vol. 47, 1962, pp. 473-484.
24. See, for example, M.E. Marts, "Use of Indirect Benefit Analysis in Establishing Repayment Responsibility for Irrigation Projects," Economic Geography, Vol. 32, No. 2 (April, 1956), pp. 132-138.
25. See, for example, M.E. Marts and W.R. Derrick Sewell, "The Application of Benefit-Cost Analysis to Fish Preservation Expenditures: A Neglected Aspect of River Basin Investment Decisions," Land Economics, Vol. 35, No. 1 (February, 1959), pp. 48-55; and W.R. Derrick Sewell and M.E. Marts, "The Nez Perce Dam and the Value of a Fishery," Land Economics, Vol. 37, No. 3 (August, 1961), pp. 257-260.
26. See, for example, D.R. Lycan and W.R. Derrick Sewell, "Pollution as an Element of the Urban Environment of Victoria," B.C. Geographer, Fall, 1967; and E.G. Pleva, "Pollution: London, Ontario, A Regional Case Study," Proceedings of the National Conference on Pollution and our Environment, Montreal, P.Q., Canadian Council of Resource Ministers, 1966, pp. 19-24.
27. J.D. Chapman, reviewing the field of geography in Canada recently, suggested three guidelines for future geographic enquiry, namely that: (1) Geographers must make a vigorous entry into interdisciplinary dialogue at several levels, (2) Canadian geographers should pool a portion of their research effort in the next decade, concentrating perhaps on socio-economic studies, and especially on water and energy studies, and (3) The Canadian Association of Geographers should make a sustained effort to improve the range and availability of data gathered by government agencies. See J.D. Chapman, "The Status of Geography," Canadian Geographer, Vol. 10, No. 3, 1966, pp. 133-144.

28. See, for example, A. Maass, et al, The Design of Water Resource Systems, Cambridge: Harvard University Press, 1962; and M. Hufschmidt and M. Fiering, Simulation Techniques for Design of Water Resource Systems, Cambridge, Mass.: Harvard University Press, 1966.
29. The most frequently quoted example, perhaps, is the TVA. The acceleration of economic growth that followed the construction of water development projects was truly remarkable. For a discussion, see Gordon R. Clapp, TVA: An Approach to the Development of a Region, Chicago: University of Chicago Press, 1955. A consequence of this experience was for river basin development to become regarded as a means of promoting economic growth, particularly in the lesser developed countries. This view has also coloured water development policies in Canada, as is illustrated in the PFRA, MMRA, and ARDA programmes.
30. Differing views about this relationship are examined in J. Spengler (Ed.), Natural Resources and Economic Growth, Washington, D.C.: Resources for the Future, Inc., 1961. See also N.S. Ginsburg, Geography and Economic Development, Chicago: University of Chicago, Department of Geography Research Paper No. 62, 1960.
31. See Gilbert F. White, "Formation and Role of Public Attitudes," in Environmental Quality in a Growing Economy, H. Jarrett (Ed.), Baltimore: Johns Hopkins Press, 1966, pp. 105, 127.
32. See Gilbert F. White, "Optimal Flood Damage Management: Retrospect and Prospect," in Water Research, Allen V. Kneese and S. Smith (Eds.), Baltimore: Johns Hopkins Press, 1966, pp. 251-267.
33. Fraser River Board, Final Report on Flood Control and Hydro-Electric Power in the Fraser River Basin, Victoria, B.C., Queen's Printer, 1963.
34. In May, 1962, the federal government signed an agreement with the Manitoba government calling for the construction of the Greater Winnipeg Floodway, estimated to cost \$63.2 million. It is due to be completed in 1968. The federal government will pay 37.5 per cent of costs of the works (up to a maximum of \$36.9 million), plus 37.5 per cent of costs of excavation.

35. For a review of these studies, see Ian Burton and Robert W. Kates, "Perception of Natural Hazards in Resource Management," Natural Resources Journal, 1964, pp. 412-441.
36. For a discussion of the role of attitudes in decision-making, see Gilbert F. White, "Formation and Role of Public Attitudes," in Environmental Quality in a Growing Economy, Henry Jarrett (Ed.), Baltimore: Johns Hopkins Press, 1966, pp. 105-127.
37. See, for example, Robert W. Kates, Hazard and Choice Perception in Flood Plain Management, Chicago: University of Chicago, Department of Geography Research Paper No. 78, 1962; Gilbert F. White, Choice of Adjustment to Floods, op. cit.; and Ian Burton and R.W. Kates, "The Flood Plain and the Seashore: A Comparative Analysis of Hazard Zone Occupance," Geographical Review, Vol. LIV, 1964, pp. 366-385.
38. Thomas F. Saarinen, Perception of the Drought Hazard on the Great Plains, Chicago: University of Chicago, Department of Geography Research Paper No. 106, 1966.
39. Robert C. Lucas, "Wilderness Perception and Use: The Example of the Boundary Water Canoe Area," Natural Resources Journal, 1964, pp. 394-411.
40. See, for example, D.R. Lycan and W.R. Derrick Sewell, "Pollution as an Element of the Urban Environment of Victoria," The B.C. Geographer, Fall, 1967.
41. T.F. Saarinen, "Attitudes Towards Weather Modification: A Study of Great Plains Farmers," and W.R. Derrick Sewell and J.C. Day, "Perceptions of Possibilities of Weather Modification and Attitudes Toward Government Involvement," both in Human Dimensions of Weather Modification, W.R. Derrick Sewell (Ed.), pp. 323-328 and pp. 329-344, respectively.
42. Estimated from data gathered in connection with the Privy Council Science Secretariat study of social science research in the water resources field in Canada. See Bruce and Maasland, op. cit., p. 25.



43. In a recent Symposium on The Geographer's Role in Contemporary Canadian Society, several participants called attention to the fact that Canadian geographers have rapidly become attuned to the major problems facing Canadian society, and that this is reflected both in their contributions to research and in the demand for their services. See N.L. Nicholson, "The Geographer's Role in Contemporary Canadian Society," Canadian Geographer, Vol. 11, No. 3, 1967, pp. 157-159; Alexander M. Blair, "One Geographer's Views on the Geographer's Existing and Potential Roles," Canadian Geographer, Vol. 11, No. 3, 1967, pp. 160-162, and A. de Vos, "The Ecologist-Biogeographer in Resource Analysis and Environmental Planning," Canadian Geographer, Vol. 11, No. 3, 1967, pp. 162-165.
44. The principal agency funding water resources research in Canada has been the National Research Council. Most of the research sponsored by this agency has been in the physical sciences.
45. Recently the National Research Council has broadened the range of topics it is willing to fund, offering, for example, encouragement for studies in the resources field, including those to be undertaken by social scientists.
46. The principal agency funding social science research in Canada is the Canada Council.
47. Several Canadian geographers have suggested that the lack of effective liaison between the universities and government agencies has severely limited the contribution of geographical research to public policy. See, for example, F.K. Hare, "A Policy for Geographical Research in Canada," Canadian Geographer, Vol. 8, No. 3, 1964, pp. 113-116.

## CHAPTER 4

# LEGAL AND ADMINISTRATIVE PROBLEMS IN WATER MANAGEMENT IN CANADA: A SUGGESTED FRAMEWORK FOR ANALYSIS

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### Introduction

Lawyers and political scientists who have concerned themselves with water management problems in Canada seem to be generally agreed that there are three major sources of such problems. These relate principally to (1) the large number of laws concerning the management and use of water resources; (2) the huge multiplicity of agencies dealing with water matters, and the general lack of co-ordination among these agencies; and (3) difficulties arising from the legal and political structure of the country.

While there is broad agreement as to the origin and nature of the problems, there is no consensus as to solutions. There have been numerous attempts to find solutions. So far, however, efforts have been impaired by the lack of a generally acceptable framework for analyzing administrative and legal problems, and by the failure to apply concepts derived from administrative theory. This chapter attempts to overcome these deficiencies.

Water management, as an administrative phenomenon, involves problems that are common to any field of organization. To this end, this chapter presents first a framework which can be applied to any problem relating to administration. It describes the different kinds of problems that may have to be dealt with, and notes types of functions which such agencies may perform in attempting to solve them.<sup>1</sup> Water, however, has a number of natural characteristics which give rise to special problems in administration, and these require appropriate responses in terms of activities, roles, institutions and processes. The second part of the chapter applies the concepts outlined in the first section to the field of water management. It identifies various problems in this field, and notes constraints placed upon solutions by the nature of the resource and by the political structure. It indicates a range of possible responses and potential legal and institutional consequences of the adoption of each of them.<sup>2</sup>

### Concepts and Techniques for the Analysis of Administrative Phenomena

Problems relating to administration may be classified according to four types of phenomena: namely, the material activities (problems) constituting an administrative area; the functional responsibilities concerned with the performance of those activities; the institutions or agencies among which are distributed such responsibilities; and administrative processes relating these institutions to each other. This chapter presents first a discussion of the various types of phenomena. These phenomena are also noted in Table 1, which describes the framework of analysis in summary form.



TABLE 1

ANALYSIS CONCEPTS AND TECHNIQUES FOR ADMINISTRATIVE STUDIESI - Administrative Activities and Operations: Content of Administrative Action

## A - Categories of Activity (or administrative functions)

- 1 - improvement of knowledge
- 2 - operation-utilization
- 3 - protection-conservation
- 4 - improvement-renewal
- 5 - distribution

## B - Types of Operations (or Nature of Administrative Actions)

- 1 - collection and analysis of data
- 2 - plans
- 3 - provision of services
- 4 - production of goods
- 5 - provision of financial assistance
- 6 - provision of equipment
- 7 - co-ordination
- 8 - controls and tutelage
- 9 - negotiation-consultation
- 10 - technical assistance

II - Administrative Roles: Modalities for Administrative Action

## 1 - Designing Roles:

- a) axiological role: forecasting
- b) regulatory role: organizing

## 2 - Management Roles:

- a) axiological role: realization
- b) regulatory role: support

## 3 - Mission Roles:

- a) axiological role: promotion-liaison
- b) regulatory role: internal controls and inspection

## 4 - Public Relations Roles:

- a) axiological role: consultation
- b) regulatory role: information

TABLE 1  
(continued)

III - Administrative Organizations: Managing Action Agents

A - Designing Services:

- 1 - General designing services: "in" general planning branch
- 2 - Functional designing services: "in" functional branches  
(according to categories of activity)

B - Management Services:

- 1 - Realization services: according to programmes and extrants
- 2 - Support services: according to intrants (personnel,  
finances, legal, records, equipment)

C - Mission Services:

- 1 - Promotion-liaison services: administrative secretariats,  
ministerial cabinets
- 2 - Internal control-inspection services: "inspectors" for  
realization agencies, "controllers" for support agencies

D - Public Relations Services:

- 1 - Consultation services: advisory boards
- 2 - Information services: dissemination services

### Categories of Activity

Whatever the area of administration, there are five different categories of activities that might be pursued. These categories are as follows:

1. Administrative activities concerned with the improvement of knowledge about a specific matter: this might include the provision of technical or scientific information, the development of techniques or equipment, or the provision of data concerning the economic and/or social aspects of the problem.
2. Administrative activities related to the operation-utilization of the goods or services provided by the area of administration. These activities concern either the operations by which the administration manages the area directly (such as in the public production of electric power), or operations by which the administration influences the area indirectly (as in the regulation of the electric power production of private power utilities).
3. Administrative activities related to protection-conservation. This involves the application of measures designed to maintain the quantity or quality of goods provided by a given region (such as in the preservation of salmon runs or scenery).
4. Administrative activities concerned with improvement-renewal. This may involve, for example, measures relating to the promotion of development or rehabilitation of facilities for the production of goods and services in a given region (as in anti-poverty programmes or resource development programmes).
5. Administrative activities concerned with distribution within an administrative area. Such activities are aimed at ensuring that interested parties are able to obtain the goods and services that are made available.



Application of the foregoing fivefold classification of activities helps to reveal gaps in administrative action. First, it shows areas of activity that are not being undertaken. Second, it indicates inconsistencies of the measures being pursued. There may be, for example, some measures that are incompatible, others that are non-complementary, and yet others that are in antithesis to the goal being sought. The classification also makes possible an economic evaluation of administrative activity. The results of the various activities can be weighed against the investment in their pursuit, and against the various alternative ways of attaining given objectives. Such evaluations would be particularly useful to administrators in setting their priorities for funds, and to legislators in deciding upon budget allocations and in drawing up management policies.

### Types of Operations

Given the five categories of activity, how are they carried out? Ten different kinds of operations may be distinguished:

1. Those contributing to the collection and analysis of data. They may include surveys, censuses, investigations, experiments, data processing, and preparation and presentation of reports.
2. Those contributing to the preparation of plans. They may be concerned with the development of objectives, and the formulation and application of policies to meet those objectives.
3. Those by which the administration renders a service. This may involve such functions as the provision of technical advice, or control of activities in the public interest.
4. Those that are related to the production of goods. This is concerned with the actual performance by an administrative agency of mechanical operations that lead to the production of goods, either processed or non-processed.

5. Those concerned with the provision of financial assistance by an administrative agency to individuals or groups of individuals. This may involve programmes ranging from grants and fellowships to subsidies, credits, price supports, and various types of tax abatement.

6. Those by which the administration puts equipment at the disposal of particular individuals. This would include such activities as the installation of instruments and the undertaking of building construction.

7. Co-ordination of operations within and among the various administrative agencies in order to make their actions cohesive and complementary in time and space.

8. Those by which the administration exercises controls over public agencies or private individuals. Such operations involve such matters as ~~taxes~~ rights, permits, standardization, registration, certification, control, supervision, inspection, conciliation, approbation of plans and standards, reviews of specifications, imposition of tariffs and examination of development plans.

9. Negotiation and advice-information operations by which the administration comes in contact with the interested parties in order to realize a common objective.

10. Those by which the administration gives technical assistance to various individuals. This is concerned with advice, information, data dissemination, promotion, education, lectures, films, publication.

The ten types of operations described above are seldom performed by a single administrative body. Usually they are shared among several agencies. This is not necessarily bad. But the sharing of functions may be that some operations are not performed at all, either because their existence has not been rationalized, or because nobody is responsible for ensuring their performance. It may also lead to extensive and costly duplications, because several bodies are frequently involved in operations of a similar nature.

The foregoing discussion has indicated that there are five major categories of activities in which administrative agencies might be called upon to participate. It has also shown that there are ten broad types of operations which might be undertaken in connection with the five categories of activities. The extent to which, and the manner in which the various operations are actually performed, however, depends upon the roles which administrative agencies, their branches, and their officers perceive for themselves.

### Administrative Roles

There are four types of administrative roles: the designing role, the management role, the mission role and the public relations role.<sup>3</sup> Each of these roles is further divided in two specialized roles: one might be termed "axiological", since the various actions of an administrative officer in performing it contribute directly to the realization of particular goals of his agency; the other might be termed "regulatory", because it involves the performance of actions which provide means for the execution of the axiological role.

The essential features of the four types of roles are described below:

- (a) Designing roles: to define the objectives of the administrative branches of a given administration (department so and so), to detail the activities of each of them, and to establish their organization and reciprocal relations;  
The axiological role is concerned mainly with forecasting.  
The regulatory role is concerned mainly with organizing.
- (b) Management roles: to execute the professional or mechanical operations necessary for the production of goods or



services for which a given administrative agency has been created. This role is the fundamental one, with regard to the others mentioned here, since it is oriented outside the administration, i.e., for the consumers of the administrative services (the clientele); The axiological role in this case is concerned with realization. The regulatory role involves support (such as the provision of financing, personnel management, legal services, material supplies and administrative equipment, files).

- (c) Misc. ion roles: to promote policies adopted, to short-circuit the flow of communications, to co-ordinate the activities of the various bodies, to see that such activities meet the requirements already specified. This role concerns only the actual functioning of services. In this sense it differs from the other three. Its axiological role is concerned with promotion-liaison. Its regulatory role involves intra-administrative inspections and controls.
- (d) Public relations roles: to inform the public about the activities of the services or consult the public about the same. Like the management roles, the public relation roles put the administration in contact with the outside (clients); The axiological role is concerned with advising. The regulatory role is focussed upon the provision of information.

The roles described above cover the various actions that could be taken by administrative agencies. If all of the roles were performed, the entire range of administrative activity would be undertaken. It will be shown later how these roles provide guidelines for setting up administrative organizations (or services).

Theoretically, an administrative service should not assume more than one role. In fact, however, each agency usually performs several roles. As a consequence, some roles are performed more or less efficiently by agencies that are not well qualified to perform them. For example, a Planning Branch may be called upon to perform the mission role and the designing function. It may undertake the latter with great competence but may perform the former very poorly. On the other hand, it does not follow that if a role is not performed by a specialized service, it is not performed at all. Generally the role is performed somewhere. The problem is that it may be performed by a service that probably should not perform it. This deficiency provides an indication of areas where reforms are required.

Specifically, a number of administrative reforms relating to the concept of role might be suggested. First a much needed reform would involve the precise identification of roles which could most appropriately be performed by particular agencies. For example, an information service might best perform one aspect of the public relations role such as dissemination of ideas flowing from the administration to the public while an advisory body might perform another aspect of the same role (such as the exchange of ideas). Second, it might be possible to introduce greater efficiency by assigning certain responsibilities, specifically to particular agencies. For example, one might assign the mission-promotion role to a Minister's office rather than to the planning service of the same department. A third type of reform would be to increase the specialization of operating agencies by making clear and exclusive their responsibilities and authority in particular fields. For instance, the staff services performing a designing role might be relieved of all operational or management services.

### Administrative Institutions

The content of administrative action (activities and operations) and the forms for this action (the managing roles), have been discussed. It is now appropriate to describe the agencies that perform these functions and assume these roles.

To define administrative agencies in a given area, and their inter-relationships, means precisely "to organize" that administrative area. The next part of this chapter, therefore, is concerned with the identification of essential requirements for the smooth operation of such an area. The utilization of the above-mentioned theoretical elements (Administrative Activities and Operations, and Administrative Roles) will enable us to identify, for any administrative area, a minimum number of necessary types of agencies, their roles, their composition in terms of members of various disciplines, the operations they perform, and their organic relations.

Organizing a given area of administration requires decisions on several matters:

- a) the work load distribution among the various agencies involved; that is, the distribution of the various operations that relate to the activities that can be identified in that area of administration;
- b) the sub-division of agencies into services, and then their classification according to specific roles which they are supposed to perform;
- c) the allocation of specific responsibilities to the various agencies, and consequently the establishment of their respective position in the administrative structure.



It appears, therefore, that the theoretical types of operations identified earlier in this chapter must be reclassified into natural groups that would be functionally compatible with the operating structure. To put it in a different way, it is evident that the various operations must be distributed between the agencies according to the role they are to perform (planning, management, mission, public relations). It appears also that the identification of the necessary administrative agencies (or services) cannot be made exclusively on the basis of the four types of roles. This is so even if it is granted that a single agency (or service) cannot in theory assume more than one role. A given role may require the establishment of several agencies (or services). The precise number will depend upon the types of operations to be performed.

### Planning Services

Planning services are operations necessary to the collection and analysis of data, and to the establishment of plans and programmes within a given administration. These are obviously staff services having in general no line responsibility over management services. There are two types of planning services: they may be general or functional, depending upon whether they assume a regulatory (general) or axiological (functional) role.

### General Planning Services

These are usually grouped under a "General Planning Branch". Such a branch will not usually develop the department's policy concerning the functions it performs in the area. This is performed by the "functional" planning services, as will be shown later. The name, however, is appropriate, since the branch has to consider the economic and other consequences of department activities and to orient the same accordingly.

"General planning services" also include those establishing a department's "internal programmes", i.e. the departmental programmes concerned with personnel management, budgetary management, publicity, organization and methods. It is important not to mistake these "internal" planning services with planning services concerned with policy formulating functions that relate to the agency's *raison d'être*. The latter services properly come under the Functional Planning Services.

### Functional Planning Services

These are the services establishing the department's policy in the various fields of action it conveys. They should normally be classified into as many branches as there are groups of activities or functions actually performed by the department in its own area: information, utilization-operation, protection-conservation, improvement-renewal, or distribution. In theory, the department should have these five functional planning branches. It may happen in practice, however, that the number is lower. This would indicate that the department does not assume all the theoretical administrative functions. In such a case, it may share them with other administrations, or it may be that the said functions simply are not performed at all.

Planning services should not be mistaken for the management services: the former establish objectives, standards and operation processes, while the latter provide the services, goods, controls, assistance, and so forth which result from the implementation of policies administered by the agency.

### Management Services

Management services are operations performed for the realization

of the objectives of the agency, whether those operations are directly concerned with undertaking a given activity, or whether they make that activity possible by providing the appropriate means. Such services are of two types, according to the role they perform: the ones that are commonly called "executive" service, for the realization-axiological role, and the so-called "common" services, for the support-regulatory role.

### Realization Services

Such services are the ones performing the operations by which a department exercises, in its own area, the information utilization-operation, protection-conservation, improvement-renewal and distribution functions.

For that reason, there will be at least as many realization service groups, or branches, in a given department, as there are functions assumed by the same, be it a "service" department (education, health, etc.) or a "resource" department (water, mines, forests, etc.).

Each one of these five branches (or service groups) could comprise a different number of services, according to the (natural) groups of operations actually performed, among the realization operation classes that are feasible in theory: namely, service providing, goods producing, financial assistance, equipment assistance, control and tutelage, or technical aid. The nature and organization of realization services should be in agreement with the organization of the administrative programmes and the nature of their "outputs" (or products). As a matter of fact such is the only concept of the administrative services that can be considered as perfectly rational, from the organic as well as structural standpoint, because it suits perfectly the intrinsic necessities of the realized action.

When a department is decentralized, its realization branches are territorial and under the authority of a common line head, himself under what might be termed the "Territorial Administration Branch" at the headquarters of the department. When the department realization services are not decentralized, they come under some central branches comprising also the planning functional services. For a given administrative area, health for instance, it may happen that a portion, or even the whole of the realization services, come under a decentralized administration which is different from the department responsible for designing (or planning) in the area: the co-ordination problems between planning and realization are thus more numerous and more difficult but not impossible to resolve.

#### Support Service

Support services supply the realization services with the operational needs they require. These include the personnel service, finance service, registry service, equipment service, and law service. Usually they come under a "General Administration Branch".

#### Mission Services

Mission services, as such, are rarely identified in the various studies of administration structures and functions. Instead, they are usually grouped with services dealing either with planning services (general) or with management services (support services). However, both in their activity and their structural ties, the mission services differ totally from the planning services, for they themselves are not concept originators but rather interpreters and promoters of the concepts developed by other services. Mission services do not aim to provide means of action for implementation services, but rather they examine



their operations; thus their position in the structure is always outside "staff" (the position of services dealing in concepts) and outside "line" (where support services fall).

Mission services do not deal with any material object but with an administrative one, so that they are not specialized in relation to any administrative sector, but cover each field without distinction. Their role is to set things going, to short-circuit obstacles, to ensure that new orientations are communicated throughout the structure, and to encourage studies and activities in keeping with priorities. To achieve these objectives, they will emphasize the functions of co-ordination and intra-administrative control.

An administrative organization which includes only those services dealing in the conception and management roles invites slow movement, compartmentalization, short sightedness and rigidity. These in turn lead to an obscured perception of objectives, inadaptability, lack of integration, and inefficiency. These structural constraints, intrinsic to all administration, can be remedied by the creation of mission services. It serves, in fact, to counteract the hierarchical rigidity of authority and its accompanying compartmentalization of work. Mission services are of two kinds, depending on whether their secondary role is axial or regulatory. This involves the provision of promotion and liaison services on the one hand, and internal control and inspection services on the other.

#### Promotion-Liaison Services

These services provide the linkages between the various concept-originating services and between these and the management and

production services. These linkages may occur within a department or between various administrations involved according to their functions (information collection and analysis, development and utilization services, protection-conservation, etc., as described earlier in this chapter).

The activities of promotion-liaison are extremely numerous: in fact they comprise the work of all the intra- and inter-ministerial committees and of the inter-departmental committees. It is important to note however that the above services do not have their counterpart in corresponding administrative services. One can only speak of a promotion-liaison service in the case where a specific agency has been created and institutionalized to carry out these functions. Thus, strictly speaking, a liaison-promotion service is the secretariat of such and such a committee, as distinct from the committee itself--a collection of individuals who assume both conception and management roles. In this way the permanency of the service is ensured, as is its legal position.

It is important to distinguish between promotion and liaison. Both are concerned with linking various services but for different purposes, and in different ways.

#### a) Promotion services

Promotion services link other services to each other, even though they operate at different levels of the administrative structure. Their aim is to promote understanding between persons in authority and those in services, indicating the correct orientation to the latter and informing the former of problems. They represent a short cut between levels of administration, thus creating a channel of communication outside a line structure of authority. This parallel channel of communication,

contrary to what one might expect, strengthens the existing line of authority. Since the promotion service is closely linked to the power of decision-making, there can only be one service of this type within any one department and it must take its place at the top of the hierarchy, i.e. within the minister's office where political and administrative authority is at its peak. Mission services sometimes exist on a temporary or ad hoc basis, but these generally resemble actual planning or management services of varying status.

#### b) Liaison Services

These are the realm of administrative secretaries who assure continuity and guarantee the efficiency of conferences and administrative committees of all kinds, which bring together either planners, managers, or both, from the same or various administrations. The purpose of such committees is to promote harmony in objectives, and co-ordination of activity between agencies having various roles; the task of the secretariats or liaison services is to prepare the work for, and to follow up on, decisions taken jointly by these committees.

In fact, administrative secretariats have a structure of services parallel to the policy-formulating and management services. There may be one specifically for each administrative function: (knowledge, operation-utilization, etc.) as long as there is a corresponding committee grouping together policy-formulating and management agencies within a particular administrative sector (water, forests, health, etc.). There may be also others, of a general character, at various levels of administration: (1) at the level of the whole sector; (2) at the level of many sectors that have natural affinities, or at least interministerial if not interdepartmental--public institutions--local communities (the

Canadian Council of Resource Ministers, for example, or the Comité Permanent d'Aménagement des Ressources in Québec); (3) at the general level of the government, or the whole spectrum of the administrative sectors (Commissariat General au Plan ou Délégation à l'Aménagement du Territoire et à l'Action Régionale in France). In any case, the administrative secretariat is a liaison device at the service of a collegiate body of co-ordination or attached to a collegiate body of decision, notwithstanding its own importance or dimension.

When it is specifically concerned with an administrative function (knowledge, operation-utilization, etc.) the liaison service will be generally attached to the corresponding operation service of policy-formulation. If it is general for a sector, the liaison service will be attached to the highest administrative authority in the pertinent administration. It will be attached to the most influential among these if there is more than one administration working in that field.

### Internal Inspection and Control Services

Like the promotion-liaison services, the internal inspection and control services, within a department, are not set up to undertake operations performed by this department to fulfill all or some of the various administrative functions (knowledge, operation-utilization, etc.) of the section that has been assigned to it. The internal inspection and control services are devices specialized in the practice of co-ordination operations. They are exclusively assigned to administrative functioning, as well as all the other mission services, within which they play the regulatory role (the promotion-liaison services playing the axio-



logical role). The operations of these services are therefore limited to the other services of a single administration.

The term inspection-control services may lead to a misunderstanding in that it might be inferred that these services perform operations of the category "controls and tutelage". The operations undertaken by the inspection and control services of a department consist not in modifying or in limiting the actions of persons outside that department but rather in examining the activity of its own agents.

a) Inspection Services

Inspection services compare objectives, criteria and methods defined by the functional policy-formulating services with the results of operations undertaken by the realization services. In theory, we could have as many inspection services as there are administrative functions (knowledge, operation-utilization). In practice, as the inspection agents are itinerant, it is preferable to create within a department, only one inspection group that will visit all realization services for all groups of activity. It is essential, however, that they be well prepared for their job the object of which will be multi-purpose.

It is suggested above that inspection agents are itinerant. In fact, the establishment of such a service can be envisaged only when the administration is decentralized; if such is the case, an inspection service becomes absolutely indispensable to tie together, outside of the live structure of authority, the functional policy-formulating services and the regional realization services, for professional ends and not live ends. The inspection services are, in fact, the eyes and ears of the functional policy-formulating services. Such a role is clearly not the

business of realization services. Their preoccupations and operations are such that they cannot and should not assume such a role.

Within a region of operation, an inspection service has a mission role similar to that which the ministerial cabinet has for the central services of the administration. It is for that reason that they are generally unknown in centralized administrations; on top of that, in such cases the functional policy-formulating services are then on location, in relation to the realization services, and in a position to make a direct evaluation of their activity.

#### b) Internal Control Services

Internal control services examine, as do the inspection services, the activity of administrative agencies by applying various criteria of achievement. However, in cases where the examination is related to 'control', it should be distinguished from 'inspection'. The comparisons in the two cases are not dealing with the same operations and are not done for the same reasons.

It is not a question this time of comparing the action of realizing services with criteria set up by the functional conceiving services in order that these criteria be respected, but rather to compare the action of the realization services with the framework and means that are put at their disposal. Framework and means of action are put at the disposal of realization services by the support services (financial services, equipment services, registry, legal and personnel).

However, it is important to make a distinction between the action of providing these means (the preparation of the budget, the

of staff, the provision of a legal opinion, etc.) and the action of controlling the use made of these means. This distinction is generally understood in the field of finance where the "budget officer" is the "comptroller of finances"; the control of equipment is also exercised by an agent that is different from he who orders them. In the field of personnel and legal service, the distinction is clearer still. The control of operations is undertaken by a body which is truly a support service: a commission of peers for the examination of hierarchical decisions relating to personnel, a centralized service to control the legal acts involved, between departments.

In contrast with the inspection services, internal control is necessary even in an administration which is not decentralized. This is explained by the fact that the control undertaken by these services has to do with operations that are the same from one administration to the next: the commitment of funds (control of legality), the control of personnel (control of uniformity), etc., which was not the case for the operations verified by the inspection services which are specific to the administrative field (water, forestry, etc.). For internal control services have a tendency to deal with the whole administrative fields (or departments) of the government and to be directly attached to a central agency in relation to all departments, in contrast to the support services that tend to be attached to a central agency having to do with a specific support sphere.

### Public Relations Services

Public relations services are those which ensure the dialogue between the administration (a department) responsible for a particular administrative field (water, health, forestry, etc.) and the other persons

interested in that field in various capacities. These services are of two types, according to the role they are playing: the consultants that play the axiological role of consultation, and the dissemination services that play the regulatory role of information.

### Consultation Services

Consultation services<sup>4</sup> bring together the policy and planning services of a department with persons exterior to that administration in order to attain an objective common to this department and to these persons. A consultant may be engaged to study the whole operation of a department or only one of the many groups of administrative activity of that department (knowledge, operation-exploitation, etc.). Theoretically, we could therefore find within a given department as many consultants as that department has functions in the field; consultants for research, operation-utilization of the field, etc. that will respectively be attached to the appropriate functional conceiving services. If we have only one consultation service for the whole department, it will then be attached to the general planning service, or better still, to the highest administrative authority in the department: the minister.

There are two major forms of consultation services: those that are purely consultative and that bring together only a collegiate body; and those that are also responsible for longer term studies and inquiries. The latter generally have a structure of internal services. We will limit ourselves to those of the first category because they have only an activity of public relations; in contrast, those of the second category are undertaking some activities of planning and policy-making and of mission. The latter are in fact services that correspond to these roles but which are disguised under a special legal status while being true public relations services.



In comparison with most administrative services, advisory or consultative councils by their nature regroup the "life forces" of the sector: the transcendent personalities, the specialists and the interests. Because their members do not have administrative status and receive no remuneration for their services; because such councils are often representative in nature, (which does not occur in many other administrative services) and finally because of the special nature of their operations, which generally consists of discussions and negotiations about documents that have already been prepared, some political scientists might not wish to consider advisory councils as administrative services. In effect, the determination of the subjects to be studied and the generation of background material is not under the council's jurisdiction, nor does the council have the capacity to influence the decision-making powers to whom their opinions are intended. But they must still be considered as administrative services, because even though they decide and execute nothing, they are closely linked to the activity of other services:

1. They are a source of norms and objectives for the authorities, in the same way as the decision-making agencies (but on different bases);
2. Once accepted by the authorities, their suggestions are adopted and carried out by the executive agents;
3. They are financed and equipped by the support services, like many other agencies;
4. They are supplied with documents and working personnel by the liaison services which supply the secretariat (preparation of papers and follow-up).

An advisory council is a consultative service composed of individuals from outside the administration. It must not be confused

with an internal administrative committee. Unlike internal collegiate bodies, which are only institutionalized (as liaison agencies) by the creation of a separate secretariat which assures them formal existence, permanence and competence, councils have their own status, independent of their secretariat. This is actually assumed by the liaison services already existing at the core of the administration. The planning agencies in France provide an example to illustrate this point: the "Commissariat Général du Plan", with its divisions and sections, is an instrument of liaison but the "Commissions de Modernisation", whose papers it prepares and where its agents generally act as reporters, are consultative bodies.

Where consultation is concerned, it is possible to have one or many complete service structures:

a) a territorial structure with a generalized function: which may range from a "regional council" (assuming the existence of a regional administration) situated near the chief administrator, at the regional level, to the "social and economic council", at the national level;

b) a territorial structure functioning in sectors: which may range from a council covering an entire sector at the level of a single region, such as the "Comites de bassin" in France, to a council covering the same sector on a national level, like the "Conseil national de l'eau", also in France;

c) a sectorial structure with a functional objective: ranging from a council concerned with a function in a single sector, like the "National Advisory Committee on Water Resources Research" in Canada, to a council performing the same function for all the sectors, like the "National Research Council," also in Canada;

d) a functional structure with a sectorial vocation (water, health,

etc.): ranging from a council interested in a single function within the sector, like the "National Advisory Committee on Water Resources Research" in Canada, to a council covering the whole of the functions within the sector, like the "Conseil national de l'eau" in France.

### Information Services

Information services are those performing the operations for the dissemination to the public of the data concerning political or administrative actions in a given area of interest.

For the dissemination of political data, no doubt a central service under a given minister is the appropriate organization. It must cover everything: such an activity would come under what is generally called an "official information agency", the specifically informational characteristic of which does not have to be established. This would not be so in the case of the organizations responsible for the dissemination of data concerning administrative activity, namely the realization of services performing technical assistance operations.

The latter in fact do give advice and prepare information documents, and so forth, relating to the outputs of such services. Information services, on the other hand, offer to the public the information documents prepared by the former (such documents being a resource for them) or give administrative information concerning the managing activity or the sectors of such activity, the administrative operations or services available, the agencies or organizations performing such services and the reasons for such action or administrative procedures. Such administrative actions are another resource for the information services.

Information service inputs are necessary either to the compilation of documents produced by the realization services, or to data concerning internal administrative actions (such as expenses relating to travel or personnel); they are measured by expenses such as postage, travel, correspondence, telephone calls, etc. The more "productive" is the information service, the more it spends for information purposes. This makes the difference between that type of service and the one responsible for giving technical assistance. Productivity is highest when the agency spends the least possible for establishing the information documents it produces.

In some cases departments will establish a reference service. This should serve all the administration organizations, and so it should be centralized. It may be useful in some instances to decentralize the reference service by the establishment of depositories in various parts of the country, province, or territory. Depositories might be set up, for instance, in the larger cities.

Information services will have as many units as there are departments. They will "follow" the departments into the field, when such departments are decentralized. There would be an obvious advantage, however, in creating information services for every sector where the activity is shared by more than one administrative body (department, public establishments, local communities), and especially when the activity is decentralized. An illustration is the French Water Information Centre.



### Management Processes

The foregoing section identified possible administrative organizations based on the content and nature of the administrative action. First, the administrative roles analyzed previously indicated some general types of organization existing in any administrative organization, according to the very nature of that political function. Second, the groups of activities and of operations discussed earlier in the chapter made it possible to determine what specific organizations are required in any administrative sector to ensure that all the administrative roles are performed. An examination of the actions that a given administrative agency is required to perform in a given administrative sector (water, health, etc.) would be sufficient now to determine the optimal organization for that agency. In order to enable us to rationalize completely the operation of the same, however, we must now introduce a new theoretical concept related this time not to the content, nature, or organization of the administrative action, but rather to its execution. This concept relates to the management processes.

### Elements of Management Processes

The elements of a management process are either material or formal. The material elements of a management process are the management action factors (resources and operations, roles and organizations) related strategically by the same process; the formal elements of a management process are the whole of the management action operational variables (time and duration of action, order of introduction of its factors and their reciprocal influence) during the process, under which such variables are related logistically. We will define the management process as an operational circuit relating the management action factors and accounting for their dynamics.

Not only do the classification of activities-operations, the identification of roles and the definition of management organizations help to identify areas of needed administrative reforms, but the action processes do so as well. In order to understand the specificity of this additional alternative for administrative reform, one might liken the administrative organization to a living phenomenon, and examine it in terms of biology as follows: anatomy-functions, physiology-roles, morphology-structures, metabolism-process. Metabolism is the series of exchanges by which a living organism maintains its homeostatic balance and adjusts itself to the various "stimuli" to which it is subjected: it involves the organs, functions and activity of the living organism. For the management organization, the goals as set to it are stimuli; the processes in which takes place the action of the agencies in order to reach them are its metabolism.

Management processes should be changed only after considerable thought, since a process reform implies that the required effects can be provided by the change. It also implies that the functional requirements of the changes being undertaken and the prerequisite of such changes, in terms of organization and action instruments (personnel, financial, legal and material), are known and can be furnished by such action. This means that we must distinguish the specific processes according to their goal, determine precisely their content according to the operations they require, and determine their operational stages according to the organizations they involve.

### Types of Management Processes

Management processes are realized through a series of stages (between organizations) in a set of actions (or operations)

strategically and logistically regulated (according to a role), and consequently they will be specified by the effect that is expected. A management process is geared necessarily for one of the three following management functions: the definition of a management goal, the realization of the same, or the provision of the necessary tools for any one of these goals. There are three types of management processes:

1. "selective" processes, involving the selection organizations, organizations co-operating in the definition of goals;
2. "effective" processes, involving the effective organizations, organizations responsible for the realization of the goals;
3. "transductive" processes, involving transductive organizations, organizations co-operating in the means used in management activity. This array of new concepts, inspired by cybernetics, will introduce management dynamics into the structural and functional phenomena of management, to which we have restricted our

the role of the services that determines in which process they are involved. As a matter of fact, all the services are involved in management processes in a certain way, since all the management services are in service to the population as their ultimate purpose. Even realization and dissemination services, like realization and dissemination services, have a role in that end, all the others have an activity that contributes to the fulfillment of goals or means. Consequently, only those management services will be considered in the effective group. All the management services are first and foremost with management; for that reason, they are included in the effective group but in either the selective or transductive groups, according to their axiological (related to the value of action) or regulatory (related to the means of action) role.

A critical examination of a given management organization reveals which individual services are involved in this or that process. The number of processes needed for the operation of a given organization is variable according to the importance of the bureaucratic development within the organization: the more the management operations are arranged in processes and the more definite are the stages determining the passage from one agency to another in the process to the specific end, the more rapid, cohesive and regular will be the operation of the organization. We could find a poorly organized set-up (characterized perhaps by an inappropriate distribution of functions between services) operating smoothly, provided the processes are well established.

It was pointed out earlier that a process is a series of operations; the operations making up a given process will be those performed by the services which are linked by the same process, and which co-operate towards the realization of the goal of the process. Possible management operations, therefore, could be organized into selective, effective, or transductive processes, since the agencies performing them have been considered as selectors, effectors, or transducers.

It seems desirable now to examine in greater detail each type of management process, the services which they link together, and the operations they determine. A summary table (Table 2) of the types of processes and their elements is included at the end of this chapter.

### Selective Processes

Selective processes are for the definition of objectives; they link the services involved (planning services, promotion-liaison



services, councils); they regulate the operations performed by such services (aggregation-analysis of sectorial data, operations for the co-ordination of the realization actions, negotiation and advisory operations concerning the management goals). Three types of selective processes may be distinguished: planning process, co-ordination process, participation process.

Planning introduces forecasting in the decision process and, for that reason, it puts the decision agencies into contact with each other. In that way, they are able to ensure that their goals take into account a common perspective. It may be sectorial (covering a single sector) or global (covering all the sectors). It may also be national or regional, according to the territory covered.

Co-ordination puts into contact the various decision agencies responsible for activity fields that are different but materially inter-related, in order to maximize the spatial and temporal cohesiveness of their decisions: it introduces into the decision process the interest factors that are common to several decisions. Co-ordination deals mainly with actions consequent to decisions as opposed to planning which, while of the same type of processes, deals rather with objectives that are prior to decisions. Both of them add a different selection circuit to the decision process.

Participation puts decision agencies into contact with some elements interested in the same action field (clients that can be other decision agencies but from different organizations), in order to specify either needs or an attitude toward a decision project. As mentioned earlier, participation may be organized on a sectorial or territorial basis.

Planning, co-ordination and participation should be organized in parallel, globally, sectorially, and territorially.

### Effective Processes

Effective processes are those concerned with realizing goals. They link the two types of effective services: realization services, and dissemination services. They regulate the operations performed by such services to that end: the servicing or production of goods, provision of technical or financial assistance, or equipment, the imposition of controls or tutelage over the actions of the population, for realization services; and the provision of information for the dissemination services. Effective processes are of two kinds: decisional and informational.

Decisional processes (or operational for realization) put into contact the various realization agencies along the execution line structure. They centralize the administrative decision elements: namely, goals, means, action conditions and modalities.

Informational processes put into contact the agencies having information with the ones which disseminate it to the population. As in the case of the decisional processes, parallel to which they should be organized, informational processes are made up of the exchanges constituting the life of the execution line structure, whether decentralized or not. They must be considered as effective processes, like decisional processes, because the agencies which they bring together (along with the realization services) are the only ones among the management agencies directly serving the population. We could be tempted to consider those as transductive processes, because they provide means. We must note, however, that (a) such means are provided to the population, not

to management, and that (b) in relation to the latter, their purpose is to provide a given end (of realization) rather than a means for achieving that end.

### Transductive Processes

Transductive processes are those concerned with providing means for the determination or realization of the management goals. They link together the transduction services, i.e. those assuming a regulatory role (among planning and support services as well as among mission services): these are the organization-methods services, support services (such as personnel, purchasing-equipment, financial, legal), and inspection-control services (that is, inspection and control over realization and support services). They arrange the operations performed by such services, and include enquiry-study-negotiation-realization operations concerning administrative reform, support service management operations, and the evaluation-adjustment-control operations of the realization and support services.

Transductive processes are of three types: administrative reform, support operations, and inspection of the functional services responsible for the realization and control of support services.

Administrative reform obviously represents a specific administrative process, even if few countries do consider it as such by institutionalizing such a role in permanent services. It links the agencies of the organization-methods services (or all the other agencies assuming such a role sometimes without being called so, such as personnel or financial agencies) with all the other types of agencies, whether of the planning, managing, "missionary", or public relations type. It does so by studying the operations of the latter and

the appropriateness of such operations to the end they are trying to attain (methods), or by considering their status and relative relationships in the perspective on an improved operation (organization). The administrative reform is concerned with the examination and modification of the action, structures and management processes considered as management means.

Support operational processes put in contact support agencies with the services using the means that such agencies have the mission to provide. As a result, there are as many operational processes as there are support fields. These include hiring, purchasing, budgeting, legislation and regulation drafting, and registry processes.

Realization functional service inspection processes in a given administrative sector (water, health, etc.) put into contact the planning agencies and the agencies performing a given administrative function (knowledge, utilization-operation, improvement-renewal, etc.). This enables the evaluation, adjustment, and regulation of the operations performed by the performers, in terms of action standards defined by the planners. This means that there is one inspection process for each function assumed in each management sector.

Support service control processes put into contact support agencies with the central controlling agencies in that field, for evaluation, adjusting and controlling the operations performed by such agencies. There is a control process for every support field. These control processes include personnel service management operation control, purchasing operation control, expenditure budgetary control, legal operation control, and filing control.



Table 2 gives a summary of the various types of processes, states for each of them their characteristic material (agencies, institutions) and formal (roles) elements. In a sense, this table is a demonstration of the application of the various concepts outlined in this chapter.

The foregoing discussion has presented an optimal composition of a management organization viewed in terms of the structural, organizational and operational phenomena that could be studied in theory. The development of a given department will be more or less developed, depending on the functions it performs in the administrative sector it belongs to and according to whether it is the only organization having authority in that sector.

The author believed that it was essential to establish this "management theory" before trying in any way to rationalize the existing management sector. Clearly, in order to modify the organization and operation of the management activities, it is necessary first to understand such activities. The techniques of analysis just presented may be used both as a diagnostic grid and as a model for comparing various management sectors.

The management sector (water, health, education, etc.), is characterized by some specific problems. Such problems require specific strategies for the management organization. There are specific organizational problems that arise in water management, as a result of the natural characteristics of that resource. These problems and possible organizational responses to them are discussed in the following section.

## Water Management as a Field of Administration: Problems and Responses

Much has been written in recent years about water management. It is not the intention here to compete with the learned workers who authored the various books and articles that have been published in this connection. Nor is it intended to present a synthesis of the numerous organizational forms in this administrative sector since this is in agreement with our systemic and systematic approach. Rather, it is proposed to identify a number of legal and institutional elements which arise directly or indirectly from the characteristics of the resource involved. As a matter of fact, the response to some of these "natural requirements" of the field explains in large part the success of such administrative forms as the Tennessee Valley Authority and the Genossenschaften in the Ruhr.<sup>6</sup> Let us deal briefly with the specific aspects of water as an administrative sector, and then with the effects of those specific characteristics of administration on the law and institutions relating to this area.

### Specific Aspects of Water Management Considered as an Administrative Sector

Considered as an administrative sector, water management has some specific characteristics which are different from those of other administrative areas such as forests, health, etc. This means that it involves management problems that cannot be handled in the same way as in certain other areas of administration.

### Functional Characteristics

Water has three important functional characteristics that have bearing on its administration. First, in contrast to other resources,

water has what might be called a "community vocation". It is vital to everyone and it is unappropriable, since it spreads throughout nature (that is in the air, soil, water courses, and in the sea). No other resource has such an obvious community characteristic, both because it fulfills a universal need and is not restricted by the limits as set by the cadastre.

Second, as a resource, water is used for numerous purposes including domestic consumption, power generation, transportation, industrial and agricultural production, recreation, and wildlife preservation. These uses sometimes occur almost simultaneously. No other resource would have such a clearly multifunctional characteristic.

Third, water is mobile. As a consequence, a given administrative activity in a given location may result in effects elsewhere in the territory, or in effects at a later time in the same place. These 'remote' effects may be even more important than the immediate effects, either in time or in space. In few other resources are the external effects of administrative action likely to be so extensive and integral. This mobility characteristic has some important implications, therefore, for administrative action.

These three functional characteristics of water considered in the administrative sector (community focus, multifunctional nature, and mobility) bring about, as far as management is concerned, some problems which are not generally met in the management of other resources. A summary of the various characteristics and their relationship to the administration of water management appears in Table 3.

### Special Management Problems

The 'community vocation' of water is generally accepted, and is usually confirmed in law. As a general rule water is regarded as unappropriable. Sometimes it is located on land to which a title may be acquired. The water, however, is communal property. Regardless of whether the government or a private individual owns the land, there remains the problem of determining who is responsible for managing the water resource and how that resource should be managed. More specifically, there is a problem of defining the relations between the management of water and the management of the lands where it is stagnating or flowing. It happens frequently, in fact, that the title to the lands, which necessarily involves the responsibility for land management, is also taken to involve responsibility for water management. This view is fallacious since the goals of water management may differ (and probably do differ) from the goals of land management. Moreover, when the lands are private property, such a connection between land management and water management may mean in fact the negation of the community vocation of water and its de facto appropriation. It is essential, therefore, to distinguish between the management of water and the management of the lands over which it is located.

The multifunctional aspect of water leads to two other types of problems as far as the management of this sector is concerned. First, there is the problem of determining allocations and priorities among the competitive uses of the resource. This involves consideration of the relationships among the various uses. Second, there is the problem of the division of management responsibilities among various organizations which have jurisdiction over the uses of the resource (such as fishing or navigation). This requires consideration of the relationships between



various managing authorities. The jurisdiction of water managing authorities relates to the various uses of water. This means that it is not the water itself but rather its uses that the managers are looking after. Since the responsibility of the managing agencies is defined according to the uses, the responsibility concerning water itself is broadly applied, if not completely ignored. As a consequence, its practical range of management is not clearly defined. It is essential, therefore, to distinguish water management from land use management and also to distinguish the responsibility concerning water management from the responsibility concerning its uses.

Finally, due to its mobility, water makes up a physical system of which we must maintain the homeostatic balance. This balance is first of all the result of the quality/quantity ratio of water within the system, which in turn is a function of the activities in the environment. These activities result in water withdrawals, disposals, and temperature changes. There is a safety limit of use that is inversely proportional to the natural input of the system. In the first place, a water management policy arises from the relationships between the various activities, knowing their nature and their effects on the balance of the resource. For this reason, it is important to distinguish water use activities from associated management activities; that is, management activities that would become necessary due to use activities. Management activities should include controls, negotiations, co-ordination, etc.

The hydrologic system is closely inter-related with other physical systems composing the environment, as well as with the various human systems that affect it or are affected by it. Consequently, it is important to develop administrative tools which will help to co-ordinate

administrative actions designed to influence the use of the environment. We must determine precisely what are the goals of environmental quality, what are the effects of policies relating to one resource (such as water) on other resources, and how the various goals can be pursued harmoniously.

### Management Constraints

A water management constraint arises from the necessary distinction that has to be made between water management and the management of the land over which it is located. As noted earlier, it is necessary to distinguish between the responsibility concerning water management and the responsibility concerning the management of the underlying land. The responsibility concerning land may be private, since it does not have any compelling community vocation, but the responsibility concerning water must be public, as required by the community vocation of water. Such a distinction between water management and land management, (the former being necessarily public but not the latter) is the only way to comply with the property rights while maintaining the communal vocation of water. As a matter of fact, in order to comply with land rights, we must agree to the free management of the same by the persons owning it for their own purposes (which will not be the same as the purposes of water management if the land is private). So there are two administrative fields, i.e. water and land. In order to ensure that water management remains public, it is not necessary to nationalize land but simply to grant the required responsibility for water to public agencies.

A second and double constraint concerning management in this sector results from the distinction between water management and use management, on the one hand, and between the responsibility

concerning water management and the responsibility concerning use management, on the other. First of all, it is necessary to individualize water management by creating a management organization (or an organization structure) that will be specifically responsible for that resource and that will introduce consequently the preoccupation for water in the management activities for this sector by ensuring the preponderance of the conservation objective over irrational objectives as far as the future is concerned. In the second place, it is necessary to bestow the organization (or organization structure), that is specifically responsible for that sector, with actual authority over the water use management organizations. This is the only way to enable it to ensure the optimal use of water; that is, a rational choice between inconsistent uses and simultaneous permissible uses becomes possible.

A third management constraint results from the distinction between water use activities (such as transportation, consumption, power, etc.) and the necessary management activities (negotiation, co-ordination, control, etc.), on one hand, and the necessity to identify the resource conservation developments as required by the resource development activities, on the other hand. We must make sure that such management activities and such conservation developments are carried out. This is essential for maintaining the balance of the natural system and for rationalizing the developments. The carrying out of the management activities required as a result of the existence of use activities will be guaranteed only if three conditions are met: namely, (a) if the whole of the operations that are related to such management activities are carried out by some specifically responsible organizations; (b) if such organizations are different from the agencies in charge of water use operations (such as Transport or Fisheries Departments, municipalities,

etc.); and (c) if such organizations are related to the operational agencies by rational and mandatory processes. The carrying out of conservation developments will be guaranteed only if an informational process is provided for between the agencies realizing developments (that is, agencies responsible for water uses) and the organization (or organization structure) specifically responsible for the maintenance of the natural balance within the hydrologic system, i.e. the organization (or organization structures) having authority over use management agencies (departments, municipalities, etc.).

#### Legal and Institutional Consequences of the Specific Aspects of Water Management Considered as an Administrative Sector

Since the natural characteristics of water give rise to special problems and constraints, it is obvious that, in order to be satisfactory from the theoretical standpoint, the institutional arrangements for water management will have to obey certain criteria and incorporate some induced legal elements.

##### Minimal Administrative Institutions

Because of the essentially public nature of the responsibility concerning water management, there are two consequences for management institutions considered in this sector: first, management must be the responsibility of a public agency, and second, that agency must be administrative in nature. The agency must be a public one because the status of such an agency must be of the same type as the responsibility that has been bestowed upon it. Since water belongs to the community, the management of that resource must come under an agency responsible to the community, from a statutory standpoint. This must be an administrative agency, which is related to the government through the hierarchical



tutelage control, but not an agency which is jurisdictional in nature, the administrative or judicial courts. Likewise, the method for managing water must be of the administrative and not jurisdictional type.

In order to have an administrative method for water management, the water managing body must be in a position to act according to present needs, and exercise unconditionally and ex officio the functions constituting the whole of the possible management activities. As is the case in the Province of Quebec) water management is not the management of lands, and when the public power is satisfied in distributing water among the rightful claimants, while managing only the water within its own limits, and while controlling the actions of the other owners in the hydrologic environment only to the extent that such actions might affect the rights of third parties or those of the public itself, then there exists a "jurisdictional type of management". It is so because water management is then controlled by land rights, and the courts are left to decide what is the law. Water management according to a jurisdictional method is the equivalent, in practice, to the absence of the public nature of the responsibility concerning water manage-

The necessity for an organization (or organization structure) specifically with water management and having authority over the water managing agencies, results in the following two types of management forms: management must be either prospective or functional. Prospective management is one based on the use of planning through the systematic satisfaction of needs, not only through a review of actions connected with old problems, but also in connection with actions to deal with new problems as they arise. It is in fact a dynamic type of manage-

ment, rather than a passive one. It is the only means to optimize water use. A functional management is one in which the various administrative roles of designing, realization, mission and public relations are distributed among organizations that are specialized in the performance of each of these roles. Such a management type is the only way to reconcile the unavoidably divergent objectives of the various managing agencies. Such objectives diverge because of the many different uses of water and because of the necessity for the conservation of the resource. The latter constraint should, of course, come first and should be the guiding principle in their activities.

The necessary performance of the activities that are involved in water use management, on one hand, and the necessary realization of the conservation developments, on the other, lead to two major considerations: first, management must be systemic and economic; second, it must be organized on a river basin basis and framed within overall development plans.

Viewed within this context, the concept of purposes of water management must be reconsidered. The purposes of management of this resource must be changed from a public service with undiscoverable or inexhaustible funds to become an industrial and commercial type of service capable of self-financing. Water in Canada is physically abundant. What is generally lacking is development. Since the developments are planned for meeting uses rather than maintaining the resource with the desirable quality and quantities, the secondary developments that are necessary for conservation purposes are not realized. There are two reasons for this situation: either there is no organization with the responsibility to plan and realize the developments, or, when such organizations

do exist, the required developments are realized only with funds that are voted annually for such purposes, and those are always lagging in respect to the needs since funds are generally voted only for resolving problems rather than for preventing problems from arising.

In order to guarantee the realization of the conservation developments, it is necessary to get contributions from all interested agencies. This means involving those with an activity which would make the developments necessary, and those liable to benefit directly and indirectly from the developments. To ask for their contributions necessarily means their introduction into the planning and decision stages of the action programme. This is equivalent to a water management concept considered as a closed economic plan, integrating the agencies having jurisdiction over the use management, into an administrative system which is under the responsibility of the organization (or organization structure) that is charged with water management itself.

To ensure efficient water management administrative organization must coincide with the natural basin. This is the only way to determine with precision what conservation developments are required, to establish for these developments an economic type of accounting, to determine in that respect the role of the agencies responsible for water management and to permit the identification-organization-execution of the activities that are involved (control, co-ordination, etc.) in the management of water uses (navigation, withdrawals and disposals, etc.).

Such are the fundamental principles that are to be followed if we want water management to be in agreement with the general administrative theory outlined above, and adapted to the specific aspects of this

administrative sector (including the natural characteristics of the resource, problems and constraints). We might call the whole structure a "minimal theoretical administrative management framework or institution", the actual applications of which may vary, from the integrated model (like the T.V.A.), to the spread out but co-ordinated, and consequently decentralized-concentrated model (such as the Agences financieres de bassin in France).

From that minimal theoretical administrative management framework a certain number of legal elements may be induced as legal instruments which will permit the application and operation of the same.

#### Induced Legal Elements

The minimal institutional management system provides guidelines suitable for planning the renewal of the present water management system or for designing a new system. In the same manner, the legal elements induced from the minimal institutional management system (or administrative framework), and consequently from the constraints, problems and characteristics of the sector, permit us to identify the main lines of a basic legal status for controlling water and its environment.

It was pointed out above that water management should be bestowed upon public management services. This requirement, however, does not always apply to water which flows over land to which individuals hold title. Consequently, it is essential to distinguish between the public law controlling water and that controlling land. In order to do this, first of all we must determine precisely the actual conditions under which



water appears to be related to the underlying property. This takes us back to the examination of the natural sources of water: underground water, springs, lakes and streams. In all such cases, however, the community vocation of water must be the underlying principle for law.

Because of the natural system under which water drains into streams, any withdrawal from water sources for every purpose other than domestic must be authorized by the managing authority. Such an authorization should be based upon criteria related to the natural characteristics of the basin, and should be given by the river basin authority. The storage or transmission of polluting wastes on the surface should be authorized, under general regulations. The injection of any substance into underground aquifers should be prohibited. Springs, line ditches and streams up to a certain flow (to be determined) are no community interest and the use (consumption) of such waters should be free, like that of the underlying property. The same applies to lakes with a capacity within a certain volume (to be determined). Any law controlling such properties however must mention the flowing elements and those concerning their natural physical changes. The disposal of wastes into such waters, which are connected to the natural system, should be regulated. Optimal water use could be ensured by a legal scheme concerning water and stream property, conferring ownership with maximum latitude consistent with public health and safety. This might be called a "general scheme" because it would apply to all the properties not covered in a special list.

For the streams with a flow in excess of the limit over which the waters become community property, and also for the lakes with a volume over a similar limit, water withdrawals and disposals must be

formally authorized according to the ecologic characteristics of the basin (system). Development activities also must be authorized according to the ecologic characteristics and according to the development plan. They should be submitted to a "general regulatory code for works and developments in streams and lakes". Such legal clauses must apply to every agency (public or private), whatever the status of land (domanial or not). Supply points for water services along such streams and lakes should be covered by a general zoning regulation. A list of streams and lakes falling under that scheme should be established. Such a scheme, which could be called a "joint purpose scheme", would reconcile the rights of ownership with the community vocation of water.

Navigable lakes and streams are state property and are controlled by the government. In such streams and lakes the public has the right to navigate and fish, these activities being under the regulations established by the administrative services managing such uses, and nothing has to be changed in that respect. Withdrawals (except for domestic purposes) and disposals bring fees to the state. The development activities, authorized and submitted to the "general regulatory code for works and developments in streams and lakes", might also bring in fees if land occupation is involved. Such measures should be opposable to all the agencies, no matter the level of their government, if they are administrative in type. Land management for the municipal supplying points on such streams should be transferred to the municipal administration. Such a legal scheme, a "public scheme for waters", should be applied to the streams and lakes as recorded on a "domanial list" comprising naturally the navigable lakes and streams, and also the non-navigable lakes and streams that are state property (the private property of the state). In order to avoid the jurisdictional type of

management, navigability should be dissociated from domaniality, the latter being established ex officio by the administration, through the recording in the "domanial list". The dividing line between the shore (public) of streams and lakes and the reparian land should be established in a similar manner.

Finally, a special legal scheme, or "special scheme for waters", should be applied to some "development special zone", where pollution is critical, where shore occupation is too dense, and where flooding probability is too high (major bottom). Under such a scheme, without the necessity of nationalizing the land, all the uses would have to be authorized by the administrative authority.

Among the four legal schemes suggested above for determining the relationship between water management and land management, two management systems seem to be useful: regulations and authorizations. The former is general and determined by the central managing agency. The latter are specific to all actual cases of usage and granted on the basis of the basin.

From the prospective type of management proceed a number of legal elements. First of all a legal system for de-pollution might be established through the classification of streams and lakes according to a qualitative list comprising four classes: (a) pure water, suitable for all the uses; (b) good water, suitable for all the uses except for consumption; (c) poor water, suitable only for some uses; (d) polluted water where all types of disposal would be permissible. A "regeneration programme" establishing a schedule under which streams should pass from a lower class to an upper class should be developed. The preparation



of the "qualitative list" should be made by the organization (or organization structure) responsible for water management, but the de-pollution operations should be performed or supervised by the basin agencies.

From functional management we must derive a new definition of the jurisdiction of the use management agencies (departments, municipalities, etc.) as related to the water management organization (or organization structure) through a "management code for water". The latter should establish the nomenclature of the various agencies, the extent of their respective jurisdiction, and specifically, it should determine which agencies are responsible: (a) for preparing the "general regulatory code for works and developments in streams and lakes", and also the regulations controlling the uses (navigation, fishing, health, etc.); (b) for granting the various authorizations as suggested above; (c) for preparing the list of the streams covered by the "joint scheme for waters", the "public scheme for waters" and the "special scheme for waters"; (d) for managing the domanial property and for defining the "dividing line" between the shores (public) and the riparian property; (e) for preparing the "qualitative list" of streams and lakes according to quality classification; and (f) for realizing the "regeneration programme". The "management code for water" must provide also for the establishment of the "Basin Authority", which is discussed below.

From the systematic and economic type of management arises the necessity to organize the drainage basin as a water market in which the developments made necessary are financed through contributions from those who need the developments or in some way benefit from them. The legal elements in this market are brought together in a "dues system", composed of the collection of fees and de-pollution taxes



(according to withdrawals and disposals), and of "works programmes" and "financing programmes", designed and applied by the basin organizations. This system would enable the Authority not only to meet the new requirements but also to realize the "regeneration programmes" applying to the basin. In this manner, the management of the basin is individualized and related functionally to the central organization (or organization structure) for water management.

From management organized on a river basin basis arises the necessity to bestow the legal status upon the basin by constituting the same into a self-governing political administrative structure. This structure should be responsible for designing, undertaking (through a deliberative assembly with taxation power) various programmes, such as "works programmes", "financing programmes" and "regeneration programmes". These programmes are established from the results of physical (quality-quantity) and economic (uses-requirements) surveys carried out by the basin authority, for which it has the necessary power. The relations between the agencies responsible for use management and the basin authority, on one hand, and the relations between the latter and the central organization (or organization structure) responsible for water management, on the other hand, are established under the basin charter granted under the above-mentioned "managing code for water".

This concludes the list of the legal elements that appear to be induced from what was termed above the "minimal management plan". It is obvious that the administrative organizations and the required processes have been dealt with here only in their basic legal principles controlling their operation. A more detailed description, presenting the results of actual case studies awaits further research. The con-

tribution here is methodological rather than empirical. It is believed, however, that it provides a useful basis upon which the latter can be based. Other types of administrative research are also needed in this field. An outline of some of these appears in the Appendix which follows.

## FOOTNOTES

1. The first part of this chapter is based on a recent article by the present author. See Lionel Ouellet, "Concepts et techniques d'analyse des phénomènes administratifs," Canadian Journal of Political Science (Revue canadienne de science politique), Vol. 1, No. 3, 1968, pp. 310-335.
2. Some of the ideas presented in the second part of this chapter were presented recently in Lionel Ouellet, "Les Institutions et le Droit de L'eau: Methode d'Identification," Water Resources Seminar Background Papers, Montreal, P.Q.: Canadian Council of Resource Ministers, December, 1968.
3. This concept of administrative role, which is used by the present author in a specific sense in this chapter, is derived from the so-called "functionalist" approach in political science. See, for example, Gerard Bergeron, Le Fonctionnement de l'Etat, Paris: Colin, 1965.
4. For a discussion of the general problem of consultation in management, see Yves Weber, L'administration consultative, Paris: Librairie Générale de Droit et de Jurisprudence, 1968.
5. For a thorough discussion of this type of management phenomena, involving the theory of cybernetics, see Lucien Mehl, "Pour une théorie cybernétique de l'action administrative," in Traité de science administrative, Paris: Mouton et Cie, 1965, pp. 781-833.
6. The Genossenschaften are co-operative associations which were established in the Ruhr area of West Germany to manage the water resources in that region on a multiple purpose basis. For a description and a discussion of their functions, see Allen V. Kneese, "Water Quality Management by Regional Authorities in the Ruhr Area," Papers and Proceedings of the Regional Science Association, Vol. 11, 1963.

TABLE 2

TYPES OF PROCESSES AND THEIR ELEMENTS

1. Concerned with Goal Determination: **Selective Process**

<u>Selection Roles: axiological roles</u>	<u>Selection Agencies:</u>	<u>Selection Processes</u>	<u>Selection Operations</u> <sup>1</sup>
1) forecasting	1) planning services	1) planning	1) aggregation-analysis of sectorial data
2) animation-liaison	2) animation-liaison services	2) co-ordination	2) co-ordination operations of realization actions
3) consultation	3) councils	3) participation	3) negotiation and con- sultation operations

1. Such operations provide with the elements necessary to the determination of goals. They tend to the establishment of the plan or programmes (sectorial or global) constituting their output.



TABLE 2  
(continued)

2. Concerned with the Realization of Goals: Effective Processes

<u>"Effecton" Roles</u>	<u>Effecting Agencies</u>	<u>Effective Processes</u>	<u>Effecton Operations</u> <sup>1</sup>
1) realization	1) realization services	1) decisional	1) Provision of services or production of goods, technical assistance, or provision of equipment, undertaking of control and tutelage
2) information	2) dissemination services	2) informational	2) information, references-data

1. Such operations are for the realization of goals. They give form to the various projects, which represent their output.

TABLE 2  
(continued)

3. Concerned with the Provision of Means for the Determination of Realization of Goals:

Transductive Processes

<u>Transduction Roles:</u> <u>Regulatory Roles</u>	<u>Transductor Agencies</u>	<u>Transductive Processes</u>	<u>Transduction Operations</u> <sup>1</sup>
1) organization	1) organization-methods services	1) administrative re- form processes	1) aggregation and analysis of management data, negotiation and reali- zation of management changes (duties, structures, etc.)
2) support	2) support services: personnel, purchasing, financial, legal	2) support operational processes: hiring, budgeting, legislation and regulation draft- ing services	2) support service management operations

TABLE 2  
(continued)

3) inspection-control	3) inspection-control services (for realization and support services)	3) inspection processes of the realization of functional services (one process for every function performed in each sector); control processes of the support services (one process for every support field: personnel, purchasing, budget, legal, registry)	3) evaluation, adjustment and control operations of the activities of the realization and support services
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1. Such operations provide or control the means necessary to the effecting or selecting agencies. They tend to the establishment of reform or internal management programmes, which constitute their output.

TABLE 3

## WATER MANAGEMENT: IDENTIFICATION METHOD

A - Specific Aspects of the Water Management Sector:			B - Institutional and Legal Consequences:	
1) Sector Characteristics	2) Management Problems	3) Management Constraints	1) Minimal <b>Administrative</b> Management Institutions	2) Induced Legal Elements
a) Community Vocation	a) Water Management different from Land Management	a) Public Responsibility for Water Management	a) Management by a Public Agency, Administrative in Type	a) Four Types of Legal Schemes (General, Joint, Public, Special), with General Regulations and Special Authorizations
b) Multifunctionality	b) Water Management different from Use Management: Responsibility for Water Management different from Responsibility for Use Management	b) Management Individualized in a Specific Organization; Authority of Such Specific Organization over the Use Management Agencies	b) Prospective and Functional Management (where the Management Functions are Bestowed upon different Organizations)	b) Legal Scheme for De-pollution; Water Management Code



TABLE 3  
(continued)

c) Mobility	c) Use Activities different from the Related Activities; Conservation Developments Made Necessary due to the Development Operations	c) The Execution of the Activities Inferred from the Identification of the Responsible Agency; the Realization of the Conservation Development through the Connection of the Use Management Agencies	c) Systemic and Economic Management (Relating the Management Agencies and those Benefiting from the Resource; Basin Basis Management, within Overall Development Plans	c) Dues System; the Basin as a Legal Person; Taxation and Enquiry Power
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## APPENDIX

A PROGRAMME FOR BASIC LEGAL AND INSTITUTIONAL  
RESEARCH ON WATER IN CANADA

The programme comprises four phases, which are methodological rather than chronological; in other words, they can all be undertaken simultaneously, although, at a given point in the research, the conclusions of the preceding phases must be known before the planned research programme can be pursued in all its phases.

While the programme itself comprises four phases, the overall research proposed within each phase is broken down into two levels of analysis: at the first level, that of judicial norms or principles on which the action of the water "bodies" is based; and at the second level, that of bodies or institutions having to do with water, whether they are public or private.

Phase 1: The Ideal

The problem in this connection is to define, on the basis of the given data of the water problem (i.e. the social requirements to be met and the natural limitations involved in water management), the theoretical elements of ideal legislation and the theoretically ideal institutional forms for water management. Thus, one would attempt first to determine the optimum system of control over water-related property (the resource and its territorial base) and the possible forms of government intervention in this sector; secondly, one would attempt to identify the institutional system most likely to attain the standards of the previously determined ideal legislation.







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